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VOL. I. JULY, 1895. NO. 1.

Modern Telephone Exchange Systems.

BY GEO. P. LOW.

I.

The development of the telephone exchange switchboard has kept apace with the growth of the telephone industry, solely in that its appliances have been able to successfully handle the business thrown upon them, but the word successfully is used in a restricted sense, as it cannot be said that heretofore large exchanges have been handled satisfactorily. In fact, the dissatisfaction expressed has been universal and emphatic, but no recourse being at hand, telephone companies have been forced to invest mountains of money in switching apparatus that was realized to be deficient in many respects. In brief, the growth of the telephone industry has placed it far in advance of the art of switchboard building, particularly in that heretofore inventors have apparently been unable to devise switchboards that could be constructed without entailing infinite complexity in wiring and almost extortionate cost.

It may be said with propriety that there has been too little originality exercised in the invention of methods of handling telephone exchanges, and that telephone engineers, having been wedded early in their experiences to the forms of switchboards now almost universally used, have unfortunately fallen into the belief that there are no "good fish in the sea." A consideration of modern telephone exchanges must, perforce, exclude reference to the earlier devices of the art, but the single observation may be made that the principal systems now universally used contain points of resemblance, if not identity, that lead to the conclusion that the efforts of the successful inventors have hitherto been confined to well trodden paths of research, and certain it is that no system presenting features showing radical or fundamental departures from the generally accepted principle of switchboard construction, has heretofore achieved prominence. The "Multiple" system has long been pre-eminent among telephone switchboards and an acknowledged authority * observed as late as July, 1893, that "it is difficult to conceive of a telephone exchange of, say, 6,000 subscribers being worked at all upon the ordinary principle, while it is a comparatively simple matter with Multiple boards;" indeed, the Multiple switchboard is described as "the nearest approach to a perfect system that has yet been devised," and it is stated that "it is now adopted almost universally for large exchanges."

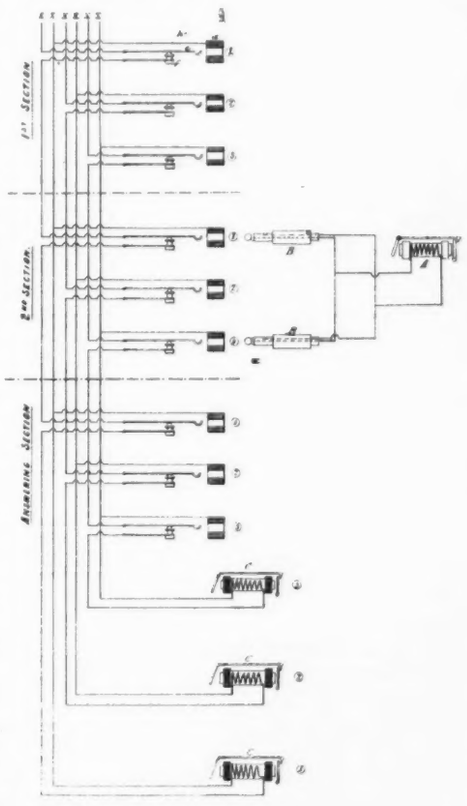

FIG. 1. THE "MULTIPLE" SYSTEM.—SIMPLIFIED DIAGRAM OF THE SERIES-MULTIPLE SWITCHBOARD.

REFERENCES.—*A, Ring-off Drop.—B, Plugs.—C, Subscribers' Drops.—X X X, Subscribers' Lines.—a, Test Thimble.—e, Tip Spring.—f, Annunciator Contact.—h, Line Closing Contact. 1, 2, 3, Subscribers' Spring-jacks.*

A number of the leading telephone engineers of America, however, who have examined a system invented and now in use by the Pacific Telephone and Telegraph Co., and which is known as the "Limited Express" system, have expressed the opinion that the "Express" system is entitled to the distinction of being the peer of the Multiple switchboard in every point as to reliability, flexibility, rapidity of switching and cost of installation and maintenance. As yet no one has been able to indicate a real disadvantage in its use, and the only criticism that has been offered, is that it does not present the feature peculiar to the Multiple board that the entire act of switching may be accomplished by a single operator.

The topic of Modern Telephone Exchange Systems, therefore, only embraces the consideration of Multiple and Express switchboards, but as the Multiple system has received extended description in other publications and as its fundamental principles of operation are well understood, it is believed that a detailed description of its plan of operation is unnecessary.

II.

It is well understood that the essential idea of the Multiple board is to enable the act of switching to be performed by a single operator, and in order to explain how this is accomplished, it is well to consider subscribers' lines as being "incoming" or "outgoing," according to whether the subscriber is a (1) "calling" or (2) an "answering" or a "called" subscriber. Each operator is capable of handling the calls of say 200 subscribers, but these "calling" subscribers will desire connection

* Preece & Stubbs' "Manual of Telephony," Page 247.

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with the lines of all subscribers in the exchange; consequently, each operator's section must contain not only the spring jacks and annunciator drops for the 200 subscribers whose calls she answers, but also the spring jacks forming the terminals of the lines of every other subscriber in the exchange. Upon this basis therefore, an exchange of 3,000 subscribers will be divided into 15 operators' sections, and as each operator answers the calls for 200 subscribers, there will be 200 subscribers' drops to each section, or 3,000 drops in all. But each operator must have represented on her section a spring jack forming the terminal of the line of each subscriber in the exchange, or 3,000 to each operator's section.

The necessity of some means by which any operator may determine whether the line of a called or outgoing subscriber is busy is readily perceived, and Multiple boards of whatever variety are provided with a test circuit for each subscriber which is brought out in the form of a tube or thimble at the entrance of each spring jack. Before inserting the plug into the jack forming the terminal of the outgoing subscriber's line, the operator touches the tip of the plug to this test thimble, and if the line of the called subscriber is engaged the operator is informed accordingly from the occurrence of a sharp click in her telephone receiver. This test thimble is shown as *a* on the accompanying diagrams of Multiple switchboards, Figs. 1 and 2.

Having these facts in mind the consideration of the different forms of Multiple boards may be intelligently undertaken.

III.

The old form of Multiple switchboard, known as the series-multiple board, is shown diagramatically, and in its greatest simplicity, in Fig. 1. It is distinctively a magneto system, as both the subscribers drops C, and the ringing-off drop A are actuated by magneto currents generated at the subscriber's station. Its characteristic feature rests in the fact that the spring-jack appearing on each section for a given subscriber is wired in series with the spring-jacks for the same subscriber appearing on every other section, hence the insertion of a plug in a given subscriber's spring-jack on any section cuts the circuits terminating in the plug, into circuit with the subscriber's line. Obviously, then, each spring-jack is liable to cause an open circuit in a subscriber's line by reason of opening at the line-closing contact *h*, which may occur from corrosion or the lodgment of dust at that point or from the weakening of the tip spring *e*, or the line-closing contact *f*. The ringing-off annunciator drop A remains across the subscribers' lines in multiple during the conversation. The series-multiple system presents no automatic self-restoring features, hence requires manual effort on the part of the operator, not only in restoring the drops, but in ascertaining whether the subscribers have performed the ringing off and other duties expected of them.

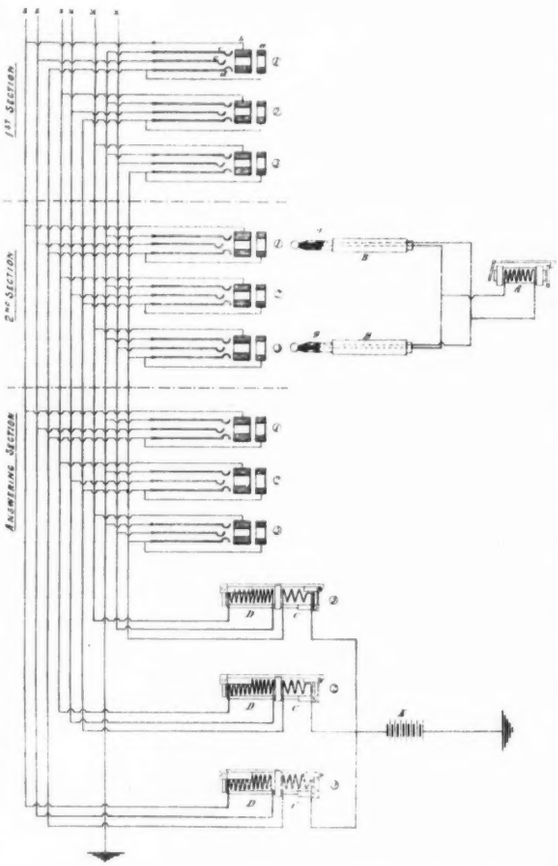

FIG. 2. THE "MULTIPLE" SYSTEM.—SIMPLIFIED DIAGRAM OF THE BRIDGING-MULTIPLE SWITCHBOARD.

REFERENCES.—*A, Ring-off Drop.—B, Plugs.—C, Self-restoring Magnets.—D, Subscribers' Drops.—E, Self-restoring Magnet Battery.—X X X, Subscribers' Lines.—a, Test Thimbles.—b, Sleeve Ring.—c, d, Self-restoring Magnet Contacts.—e, Tip Spring.—g, Insulated Metallic Ring.—1. 2, 3. Subscribers' Spring-jacks.*

These and other defects of serious importance led to the designing of the Bridging-Multiple switchboard, the simplified circuits of which are shown in Fig. 2, in their most perfected forms. As its name implies, the characteristic of the bridging system lies in the arrangement of the subscribers' jacks, the spring-jack for a given subscriber being "bridged" or wired in multiple with the spring-jacks for the same subscriber appearing on every other section, thereby obviating the troubles common to the Series board from the opening of circuits at the line-closing contacts in the spring-jacks; but in obviating one trouble a second, though less serious one, is encountered, namely, the liability of short-circuiting from the enormous amount of parallel wiring.

The most approved forms of bridging-multiple boards contain automatic or self-restoring subscribers' drops, actuated by a battery, shown as E, in Fig. 2. The plug B contains a metallic ring *g* placed near the tip and insulated therefrom. When inserted in the spring-jack this ring *g* short circuits the springs *c d*, which closes the circuit of the battery E through the restoring winding C of the subscribers' drops D, thus relieving the operator from restoring the drop after having answered the call. The act of inserting the plug B in the spring-jack cuts into the subscriber's line in multiple through the contacts of the sleeve and tip of the plug with the sleeve ring *b* and the tip spring *e* respectively. The ringing-off or clearing annunciation must be rendered by the subscriber actuating the ringing-off drop A, as in the series-multiple system.

In order that a more clear understanding of the details of operation of multiple boards may be had, it is well to refer again to Fig. 1, which, as stated, illustrates diagramatically the most approved form of the series-multiple switching system as used preferably on metallic circuits. In this the three subscribers' lines XXX, etc., are shown entering three sections of the board, the last of which is the "answering," or "local" section—that is the section answering the calls of the three subscribers located thereon. The plan of circuit wiring, shown in the first and second sections, describes the manner in which all remaining sections of the exchange are wired, and of course, each of these other sections forms the answering section for a particular group of subscribers entering the exchange, as previously described.

It will be noted by reference to Fig. 1 that one side of the subscriber's line, when it reaches the switchboard,

is cut into *in series* by as many spring-jacks as there are sections to the board, while the other side of the subscriber's line continues on uninterruptedly paralleling the first side of the line until together they reach the subscriber's annunciator drop, shown as C, but at each point where a spring-jack is cut into the first side of the line, a tap or branch wire is taken from the second side of the line and continues on to the test thimble *a*. If, now, the function of the spring-jack be considered as opening the subscriber's line at the contact *h*, by lifting the tip spring *e* from the annunciator contact *f*, then the spring-jack becomes a simple series device for opening the line. If the function of the spring-jack be considered as a means for enabling a plug circuit to be bridged or cut in, *in multiple* with the subscriber's line through the contact of the tip spring *e* and the test thimble *a*, with the tip and sleeve respectively of the plug B, then the spring-jack becomes a simple multiple device for bridging on to the circuit at any section. In point of fact the spring-jack performs both these functions, hence the insertion of a plug in the first section opens the subscriber's line on all points beyond that section, which explains why the signaling back of a called subscriber does not throw the drop of that subscriber on its own particular answering section.

The second side of the subscriber's line referred to constitutes the "test wire," the use of which will be understood when it is stated that the wiring of each pair of plugs is grounded through a small battery and retarding coil and that each operator's receiver is also grounded, so that if the spring-jack for a given subscriber is in use on any particular section a grounded battery current will be thrown upon the test thimble of each spring-jack for the same subscriber in every other section, hence the touching of the tip of the plug to the test thimble will complete the grounded battery circuit, giving the sharp click in the operator's instrument, previously referred to.

Beyond this apparatus the operators' tables are equipped with listening keys and ringing keys, together with the ringing-off drop A.

Fig. 2, showing a simplified diagram of the bridging-multiple switchboard, represents the most approved form of Multiple switching. The spring-jacks differ from those in use on the series board in that they have five terminals, two of which, the test thimble *a* and the self-restoring magnet spring *d*, are common points and, forming the test wire, are continued to each section. The self-restoring magnet wire ending in the spring *c*, and which is grounded, is common to every spring-jack in every section. The spring-jack, therefore, has three separate and distinct uses. First, to enable the cutting of a plug circuit into circuit in multiple with the subscribers' lines XX. Second, to enable the operator to apply the "busy" test by touching the plug switch to the test thimble *a*, and third, to restore the subscriber's indicator by short-circuiting the springs *c d* through the plug ring *g*. The subscribers' indicators contain two windings, as shown at D and C, which are respectively used for throwing the annunciator drop, by means of the subscriber's magneto current, and for restoring this drop by means of current sent through the coil C from the battery E, when the spring-jack points *c d* are short circuited. The test wire circuits are operated in a manner identical to that used in the series-multiple system, which the bridging-multiple system further resembles in the arrangement of the ringing-off drop A.

Experience has proven that the bridging-multiple system is far more reliable than the series-multiple board, particularly for its greater immunity from trouble and because of the self-restoring features of its indicators. Like the series system, however, it requires a manual test for "busy" and for checking subscribers who do not ring off. It also has the disadvantage of maintaining devices, such as the ringing-off drop A and the subscriber's drop D, permanently across the circuit which, together with the use of grounded circuits for special work, is oftimes seriously objectionable. While the bridging-multiple board is less liable to trouble than the series-multiple board, it is at the same time harder to find such troubles as do occur. A recent writer,* commenting on this fact, points out that with the older styles of switchboard, in which the insertion of a plug cuts out the drop, it is an easy matter to test all wires from one of the sections of the board itself; but, with the bridging type of board, the case is more difficult as the drop is never cut out, and a line will show closed through the drop irrespective of its condition outside the office.

In order that an idea may be conveyed as to the difficulty attending the localizations of switchboard "faults," it may be well to describe a method due to Mr. Manson, in which subscribers' lines are handled by bridging multiple boards and consequently with normally open spring-jacks and high resistance subscribers' indicators.

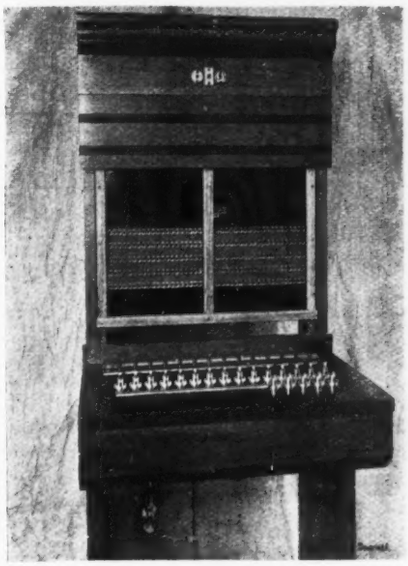

FIG. 3.—THE EXPRESS SYSTEM.—A COMPLETE SECTION OF THE "A" SWITCHBOARD.

The peculiarity of the method is in the arrangement of the testing outfit, which is a modification of the Wheatstone bridge. Its essential features are a differentially wound relay; that is, a relay having two windings, A and B, each of equal resistance and connected in series; a third wire terminating in the hammer of a telegraph key being run from the middle connecting point. A second feature of the testing set consists in the use of a resistance equal to that of a regular subscriber's indicator drop. The set also contains a suitable battery and an ordinary plug with flexible cord to connect into any spring-jack desired.

The arrangement of these devices is such that the key and battery are bridged across from the middle point of the differential relay, shunting the differential

* James W. Manson, Electrical Engineer (N. Y.). Nov. 28, 1894.

relay coil B and the resistance in series on one side, and the differential relay coil A and the plug in series on the other, thus balancing a known resistance against whatever resistance there may be on the circuit of the spring-jack into which the plug is placed.

To make the test the plug is inserted in a spring-jack, and the key closed. In case the line is open at any point outside the office, the current from the battery divides equally between the two coils, A and B, of the differential relay, with consequently no effect on its armature. If, on the contrary, the line is intact, coil A gets more current than coil B, as the joint resistance of sub-

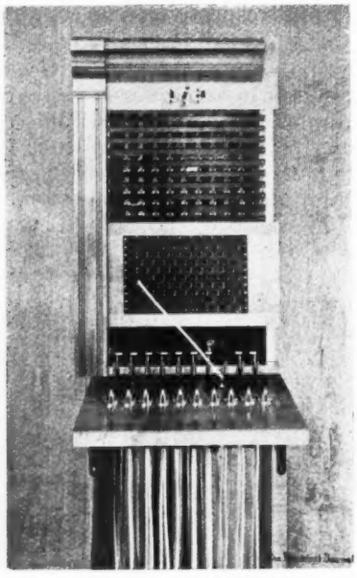

FIG. 4.—THE "EXPRESS" SYSTEM.—A COMPLETE SECTION OF THE "B" SWITCHBOARD.

scriber's line and drop in parallel is less than that of R. When a line is closed then the relay armature is attracted with an intensity proportional to the difference between the currents flowing through the coils A and B.

Regardless of the many deficiencies of Multiple switchboards, whether of the series or bridging-multiple forms, they have constituted the most serviceable appliance available, but their chief drawback, and which alone would have long since condemned them had there been a qualified substitute available, lies in the great complexity and detail of the wiring essential to their construction. When it is remembered that in the case of 3,000 subscribers, as cited, there must be 45,000 spring-jacks in an exchange using the Multiple board, and when, as is seen by reference to Fig. 2, each spring-jack necessitates the use of five wires to connect its working parts to the main wires running through from section to section, the appalling complexity of the wiring of a Multiple board in a large exchange will be appreciated, as will also the fact that the expense of installation and the cost of maintaining it free from troubles are important items.

IV.

The "Express" system, which is the joint invention of Messrs. John I. Sabin and William Hampton, is so radically different in principle from "Multiple" systems that at first impression it appears to be seriously complicated, but when its working principles are understood the idea of complexity vanishes. Aside from its thorough practicability, moreover, it presents many novel, interesting, invaluable and distinctive features. The system has been in use in San Francisco for nearly two years, and while the perfected methods of operation, as hereafter described, have not been carried out with each subscriber, yet each feature presented has been fully and extensively tested under actual working conditions and its reliability has been demonstrated. Rapid progress is now being made in changing the equipment of the Pacific Telephone and Telegraph Company so that it will conform fully to the perfected "Express" system, as herein described. Two years ago the "Multiple" system was abandoned and experiments were undertaken in line with the ideas herein set forth, and as a result of the evolution of the perfected "Express" service San Francisco to-day contains a mixed telephone system in which the use of the perfected "Express" predominates, but in some cases metallic "Express" is connected to grounded "Express," or to metallic or grounded magneto service, or grounded "Express" is connected to grounded magneto lines, and grounded magneto lines are connected to grounded magneto lines through grounded or metallic "Express" system, all with far greater satisfaction from every point of view than is possible in the use of "Multiple" boards.

A distinguishing feature of the Sabin-Hampton "Express" system rests in the fact that the switchboard is split into two sections, each independent and different in design from the other and each performing a separate or individual function. These two sections are arbitrarily designated as "A" boards and "B" boards respectively, and the same mode of designation follows through all features of the "Express" system. There are, for instance "A" operators and "B" operators, and "A" trunks and "B" trunks, etc., which at once defines the purpose of the operator or the trunk. Subscribers become "A" and "B" subscribers according to whether they are the calling or "incoming," or the called or "outgoing" subscriber. It is upon the distinction between these terms that the basis of the "Express" system rests, and a full comprehension of their significance must be attained in order to enable the system to be described understandingly.

It may be said with accuracy, though in a general

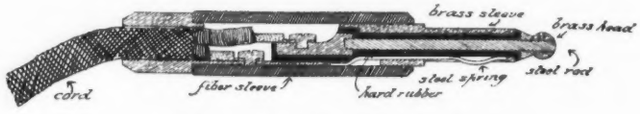

FIG. 5.—THE EXPRESS SYSTEM.
SECTIONAL VIEW OF A CORD PLUG.

way, that the calling, or incoming subscriber, is handled by "A" equipment, while the called or outgoing subscriber, is handled by "B" equipment. One hundred numbers constitute a section on either board, and each section of the "B" board contains the permanent spring jack terminals and subscriber's indicators of the lines of the subscribers on that section, together with the cords and plugs for a limited number of local trunks and their clearing-out indicators and ringing-up magneto keys, as shown in figure 4. Each section of the "A" board (illustrated in Figure 3) contains spring jacks forming the terminals for the set of local trunks going to the "B" board and known as "B" trunks, and also cords and plugs leading from the "B" board and known as "A"

plugs. This simple arrangement, together with the visual indicators and various keys for switching the operator's instruments into circuit with calling subscribers or "B" operators, forms practically the entire equipment of the "A" board.

The "B" board is therefore the subscribers' lines' board, and it is, in brief, a counterpart of the ordinary multiple switchboard, with the exceptions that in the "Express" system each section contains only the subscribers' annunciators and spring jacks for one hundred subscribers, together with not exceeding twenty trunk plugs, while in the multiple system each section contains not only the subscribers' annunciators and spring jacks for that particular section, but also spring jacks for every subscriber received on every other section, often reaching thousands of connections, as fully explained heretofore. Clearly, then, the "B" operator in charge of a given section has in her care mainly the subscribers' annunciators and jacks of that particular section, and is dependent upon using trunk lines for making connection with other sections. She perceives when a subscriber on her section is making a call, and with a single, simple motion, sends the call over to the "A" board for another operator to take care of, but when a subscriber on her section is called she rings him up and sees that he responds. Almost the entire work of the "B" operator, therefore, consists in switching for the outgoing subscribers on her section, and she is therefore considered as the operator in charge of a section of outgoing or called subscribers—in brief, a "B" operator.

An understanding of these divided boards and of the trunk lines may be attained by defining "A" operators and switchboards as affording facilities for the manipulation of such temporary extensions of subscribers' circuits as the "B" operators may make by plugging subscribers' lines over to the "A" board through the extension or trunk lines. The "A" board must therefore, be considered as the means by which a temporary "jumper," or "bridge," may be run connecting the calling subscriber's spring jack in one section of a "B" board with the spring jack of the called subscriber located in another section of the "B" board. If, now, a primitive exposition of the principles of operation of the "Express" system is desired, it can be given in no more simple way than to state that the proper operators on the "B" board extend the lines of the calling and called subscribers over to the "A" board where an "A" operator brings the lines together, thereby closing the circuit and establishing communication.

V.

In practice, however, the execution of the apparently simple act of connecting two subscribers lines together, becomes quite complicated when it has to be accomplished to the full satisfaction of the exacting demands of metropolitan telephone service. To do this, the additional equipment necessary in the making of switch connections within a single exchange operated on complete metallic service, consists of a number of accessory devices about to be described.

Cords and plugs are the devices used for making switchboard connections on account of their flexibility and ease of manipulation. They are double pole throughout; that is, each cord contains two separate conductors terminating in the sleeve and tip of the plug, respectively. The plug used in the "Express" system contains a distinctive feature in the placing of a stiff steel spring axially along the surface of the sleeve, thereby insuring a firm and reliable mechanical contact between the sleeve and the tube of the spring-jack as shown in the sectional actual size view of the plug exhibited in Fig. 5.

The spring-jack used in the "Express" system is a very neat and compact device, mounted on hard rubber, and shown as B in the accompanying illustration (Fig. 6), of a decade of subscribers' spring-jacks taken from the jack section of a "B" board. Its working parts are best described by reference to Figure 7, which illustrates the "B" board diagramatically, and from which it will be seen that the jack consists of two springs *a*, *b*, normally in firm contact with the points *c*, *d*. These springs *a*, *b*, form the terminals of the subscriber's line, and the fact that each subscriber has but a single spring-jack and consequently but a single line terminal in the whole exchange, should be emphasized, as it is a distinguishing feature in the "Express" system. The points *c*, *d*, form the terminals of the subscriber's battery, and as the jack-springs *a*, *b*, are normally in contact with the points *c*, *d*, it is clear that when the line is not in use the potential of the subscriber's battery is upon it.

The description of the subscriber's telephone equipment, which is given elsewhere, points out the fact that when the receiver is on the hook, the subscriber's line is open so far as the subscriber's battery is concerned, with the battery upon it, and also that the act of raising the receiver from the hook, closes the line and battery through the receiver and the secondary of the induction coil. It is in the subscriber's spring-jack that the battery connection with the subscriber's line is made by reason of the pressure of the springs *a*, *b*, against the points *c*, *d*, but before the battery reaches the points *c*, *d*, in each subscriber's spring-jack, it passes through the individual annunciator drop or subscriber's indicator for that particular jack. Clearly, then, the raising of the subscriber's receiver from the hook closes the line circuit through the telephone, the secondary of the induction coil and the annunciator drop on the "B" board, and clearly, also, will the insertion of a plug into the spring-jack of the subscriber indicated upon the subscriber's drop, restore the gravity annunciator drop through the breaking of the contacts between the springs *a*, *b*, and the points *c*, *d*, respectively, and at the same time remove all connection between the subscriber's calling battery and the subscriber's line.

Trunk lines are used only for conversational purposes by subscribers, and are not called upon for office duty between operators or otherwise. Their specific utilization consists in the making of temporary extensions of subscribers' lines between "B" boards and "A" boards. The trunk lines are divided into two classes, known as main trunks, or those extending between branch and main offices and local trunks, or those extending between the "A" and "B" boards of a single office. Main and local trunks are each in turn divided into two classes, namely, "A" and "B" trunks. "A" trunks are those running from incoming "B" boards to "A" boards, and have each end terminating in a plug, while "B" trunks are those appearing on the "A" boards as spring-jacks and run to outgoing "B" boards direct, where they terminate in the form of plugs. It is through the use of local trunks, therefore, that the lines of conversing subscribers are extended from their permanent sections on the "B" board to a given section of the "A" board. "B" trunks invariably extend as outgoing from an "A" section spring-jack to a "B" section plug without being interrupted by any switching or other device, as will be shown, but "A" trunks are each cut into by the intermediate cross connecting board, or the distributing board on the way from the calling subscriber's, or the incoming "B" board to the "A" board.

Upon tracing the route of exchange switching it will be found that the incoming "B" operator, or the one having charge of the section upon which a call originates, will plug a local "A" trunk into the calling

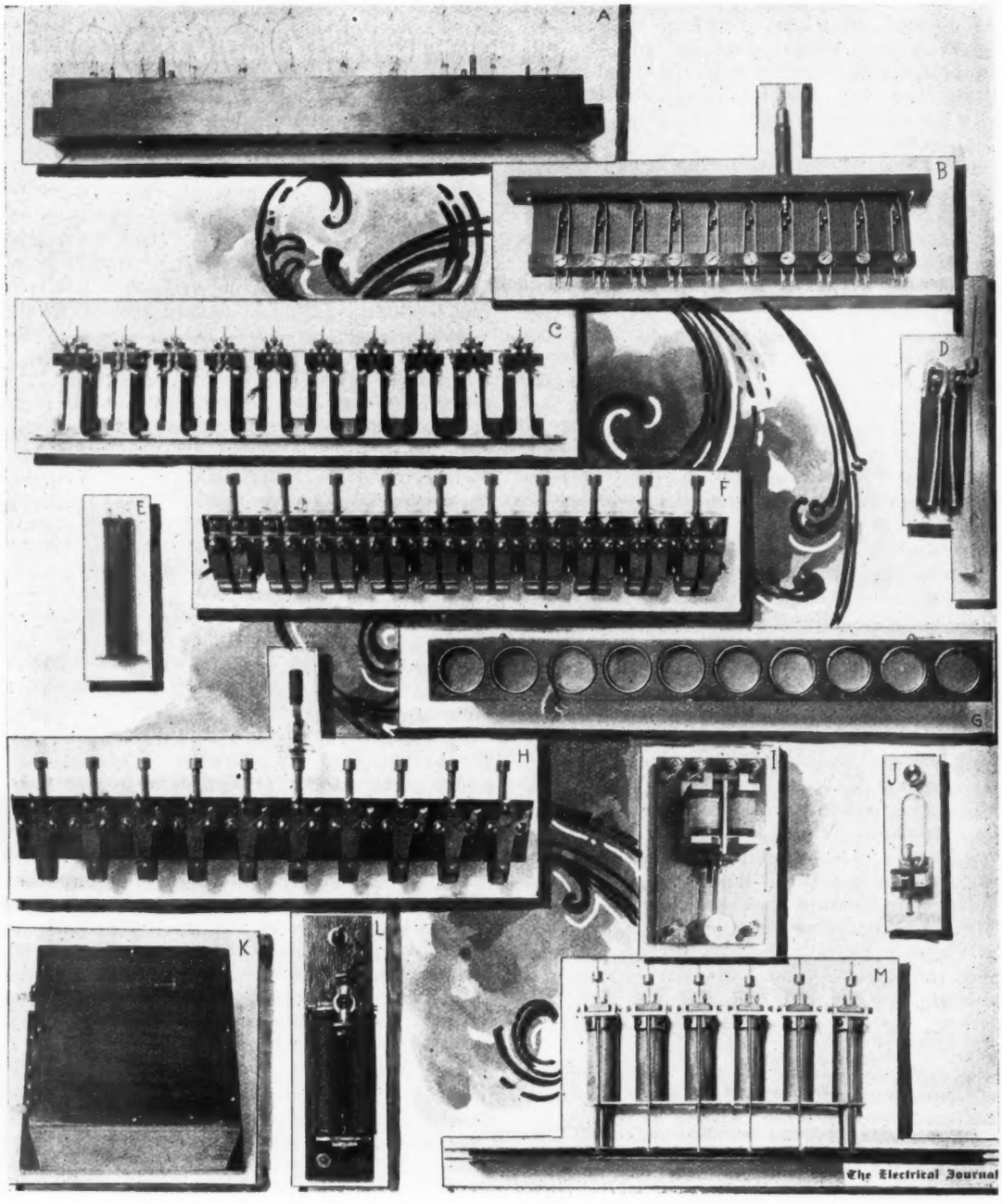

FIG. 6.—THE "EXPRESS" SYSTEM.—SOME DEVICES USED.

REFERENCES.—*A, Trunk Indicator Lamp Rack.—B, Decade of Subscribers' Spring-jacks showing Battery Contact Points and mode of Inserting Plugs.—C, Decade of Subscribers' Self-restoring Drops, with aluminum Shutter.—D. Trunk Clearing Indicator Relay.—E, Balancing or Retarding Coil.— F, Decade of Ringing Keys, the Reverse Side of which is per H. G, Cover for Lamp Rack A.—H, Decade of Listening Keys.—I, Compound Relay.—J, Plug Gravity Lamp Indicator Switch.—K, Condenser.—L, 1.000-ohm Relay. M, Magnetic Trunk Clearing Indicator.*

subscriber's spring-jack. This "A" trunk does not take the call through the "A" board direct but constitutes the first division of the entire "A" trunk or the division which extends from the "B" board to the intermediate board. From the intermediate board, the second division of the "A" trunk is continued to such particular section of the "A" board as may have been predetermined by the chief operator, who regulates the number of "B" sections each "A" operator is to handle as incoming according to the methods shown in the detailed description of the intermediate board. It is from the intermediate board therefore that the call continues along the second division of the "A" trunk until it reaches its proper "A" plug on the "A" board. The "A" operator then plugs this "A" trunk into the spring-jack forming the terminal of the proper "B" trunk, which carries the circuit to the section of the "B" board containing the called or outgoing subscriber's spring-jack where the only remaining opening in the circuit is closed by the outgoing "B" operator, all as fully described hereafter. Trunk lines have condensers in circuit and also the indicator batteries and devices, affording means for manipulating indicator signals as will be shown.

VI.

It is well known among those who are familiar with telephone exchanges that during certain hours of the day there will be comparatively little business to handle, while at other hours each and every operator will be kept exceedingly busy and the exchange will be running to its full capacity. It is this situation that led to the designing and use in San Francisco of a special distributing switchboard called the intermediate cross-connecting board, which affords the means by which the business received by the "A" board from the incoming "B" board may be split up and evenly apportioned among the operators handling the various sections of the "A" board. There are furthermore certain hours, particularly at night, when a single "A" operator can handle all the "A" board switching, in which event every section of the "B" board may be thrown upon say two sections of the "A" board by properly switching the local "A" trunks thereto at the intermediate board. Then, at other times of day, the rush of business will be so great that it will be necessary for each "A" section to be worked to its fullest capacity, in which event the "A" trunks will be so commutated at the intermediate board that each section of the "A" board will be called upon to handle the incoming switching business of say two or three sections of the "B" board. There is, therefore, no fixed or permanent connection between given "A" sections and given "B" sections of the switchboard, nor does a given "A" trunk starting at a given "B" section have a fixed or permanent terminal at any given section of the "A" board, but the "A" trunks connecting the "A" and "B" boards are changed during the day according to the volume of business transacted. This is done through the intermediate board, which cuts into the "A" trunks only and is so designed that its upper portion contains rows of spring-jacks forming the terminals of the division of the "A" trunk, which ends at the "A" board. Inasmuch as each section of the "A" board receives the incoming business of fifteen "A" trunks, it is advisable that there should be as many horizontal rows of spring-jacks on the intermediate board as there are sections on the "A" board, and also that each such row should contain the spring-jacks forming the terminals of the fifteen "A" trunks belonging to a given "A" section, as in this way a glance at the intermediate board instantly conveys information as to the distribution of incoming work among the various sections of the "A" board. In like manner the lower portion of the intermediate board contains the plugs forming the permanent terminals of the division of the "A" trunks running to the "B" board. These plugs are similarly arranged in rows corresponding to the "A" trunk plugs on the "B" board with the exception, however, that each "B" board contains but ten "A" trunk plugs, hence each horizontal row of plugs in the intermediate board should preferably contain ten plugs. It is found by experience that during the busiest hours, two sections of the "A" board will handle all the incoming business of three sections of the "B" board when operated to its fullest capacity, and as all sections are designed to satisfy maximum demands, exchanges are so laid out that there are two "A" sections to each three "B" sections. The upper portion of the intermediate board, therefore, contains fifteen times as many spring-jacks as there are sections to the "A" board, while the lower portion contains ten times as many cords and plugs as there are sections to the "B" board. Frequently, the first two or three "A" trunks of each section of the "B" board will be grouped together and plugged on to the spring-jacks forming the terminals of the "A" trunks leading to two sections of the "A" board; at other times three given "B" sections that are very busy will be trunked to two given "A" sections while the business of the remaining "B" sections may be such that one "A" operator can handle the business of half a dozen or more "B" sections, etc. No delay in answering calls or otherwise is occasioned through the use of the intermediate board.

The "Express" system, as at present used in San Francisco, is operated through intermediate boards as described, and their use has always given perfect satisfaction, but it is now believed that equal satisfaction and greater simplicity will be derived by dispensing with their use and connecting the "A" trunks of given "B" sections to given "A" sections permanently. When this is done a red lamp on the "B" board can be connected in series to the proper red lamp on the "A" board, thus enabling them to be lighted simultaneously and thus dispensing with the use of the trunk line clearing indicator or relay on the "B" boards, as shown.

VII.

Listening keys (shown as *H* in Figure 6) are used for cutting "A" operators' instruments on any particular section of the "A" board into the lines of such calling subscribers as the "B" operators may extend over to the "A" boards. "A" operators and boards alone are provided with listening keys, hence only "A" operators can converse with subscribers.

Order wire keys (see *F*, Figure 6) are also placed on "A" boards alone, and may best be described as exchange service keys. Their function is to enable any "A" operator to speak with the operator of any desired "B" section, and they are used for such service exclusively. Each order wire may be considered as originating permanently in the head telephone of the "B" operator for a given section of the "B" board, whence it continues to the corresponding order wire key of each "A" section. Order wire keys bearing corresponding numbers—that is for corresponding sections of the "B" board—are wired in multiple, and as the keys are normally in open circuit, and as each "A" operator is provided with an individual order wire key, any "A" operator may call up any "B" operator at will by depressing the proper order wire key. "B" operators, therefore, can be called only by "A" operators; hence they cannot call up any subscriber or any operator. They have no means for listening to conversations between

subscribers and can talk only with such "A" operators as may call them up over the order wire. "A" operators to the contrary, as has been shown, can cut their instruments into conversations over subscribers' lines passing through their boards, or into circuit with any "B" operator at will.

Subscribers' "Express" equipments are arranged for full metallic service, as shown diagramatically in Figure 7, illustrating the simplified circuits of the system when

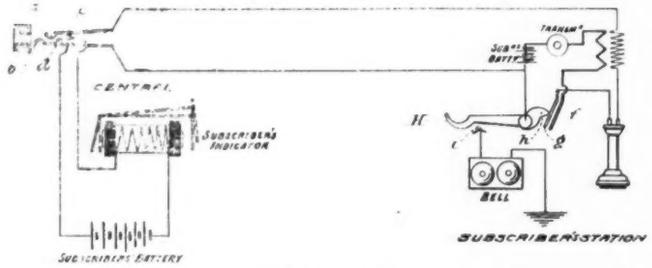

FIG. 7.—THE "EXPRESS" SYSTEM.—DIAGRAM OF SUBSCRIBERS' STATION, SPRING JACK AND SELF-RESTORING ANNUNCIATOR INDICATOR.

the receivers are off the hooks and the instruments are in use. The weight of the receiver on the hook *H* depresses it, maintaining an open circuit between the hook point *h* and the springs *f g*, at the same time grounding one side of the line through the magneto call-bell at the point *i*. Upon raising the receiver from the hook, however, the ground is taken from the circuit and call-bell by breaking the contact *i*, and the line circuit is completed by the pressure of the hook point *h* against the springs *f g*, which closses the local battery circuit through the transmitter and the primary of the induction coil, and also closes the line circuit through the receiver and the secondary coil. As described elsewhere this closes the subscribers' battery circuit that is always upon the subscribers' line when in use, and thereby transmits the subscribers' call to the proper indicator on the "B" board. The action of the hook, therefore, closes the subscribers' line when in use, and opens it when idle with the telephone on the hook.

VIII.

The automatic indicators, which form a characteristic feature of the "Express" system, give continuous visual indications from which the operators ascertain the condition of each and every circuit at a glance. Their scope of utility is most comprehensive, for they not only relieve the public from any responsibility in calling up central or in ringing off, but they faithfully subserve every function hitherto performed by operators in restoring indicators, testing for "busy," listening for responses, ascertaining if conversation is yet in progress, or in looking after renegade subscribers who are never known to "ring off." Moreover, through their use it becomes impossible for operators to make mistakes in switching without having their attention called to the error. Beyond this a further advantage in the use of visual indicators rests in the fact that in relieving operators of the labor of listening to ascertain when the line is clear, the indicator system enables them to restore the lines when clear with far greater celerity than can possibly be done otherwise. As a result a greater number of subscribers can be handled over a given number of trunks cleared by visual indicators than will be possible by any other means.

These indicators are conveniently arranged on both "A" and "B" boards, and are actuated by the calling and called subscribers respectively when they have completed the conversation and have replaced their telephone receivers on the hooks. Inasmuch as the act of switching requires the momentary attention of three operators, namely, an incoming "B" operator, an "A" operator, and an outgoing "B" operator, it is necessary that each operator should have reliable and instant notification of work to be done and concerning the condition of all circuits under her control. Accordingly, the chief functions of indicators are: First, to notify the proper operator of the existence of a call; second, to warn of improper switching or the failure of a subscriber to respond, and third, to convey such information as is necessary to enable the operator to ascertain the condition of the circuit until the conversation has ceased and it is time to clear the lines. All this is done automatically and by visual signals without the slightest effort on the part of any operator in cutting into lines, listening for conversations, or without a ringing-off signal by the subscriber or any manual effort whatever on the part of any one.

The operation of a reliable and comprehensive system of indicators is best accomplished through the placing of the indicators with their accompanying battery and balancing coils across the conductors of a trunk line. This is done in the manner shown in Figure 9, where the indicator battery and retarding or balancing coil are placed across the "A" trunk. The indicator is connected to the tip side of the trunk, that is, to the wire leading to the tip side of the trunk plug, while the retarding coil is connected to the opposite or sleeve side of the trunk with the indicator battery in circuit between the indicator and retarding coil, thus preserving an inductive balance on each side of the battery. In order that the automatic signalling of a calling subscriber when he has completed a conversation should not interfere with the automatic signals sent to the outgoing "B" board by the called subscriber at the same time, the condenser shown as *C* in Figure 9, and which has a capacity of one microfarad, is inserted in the indicator side of the "A" trunk, which breaks the metallic conductivity of the wire, but not its telephonic or inductive continuity. In no other portion of the "Express" system are condensers used. It is obvious, then, that the presence of the condenser

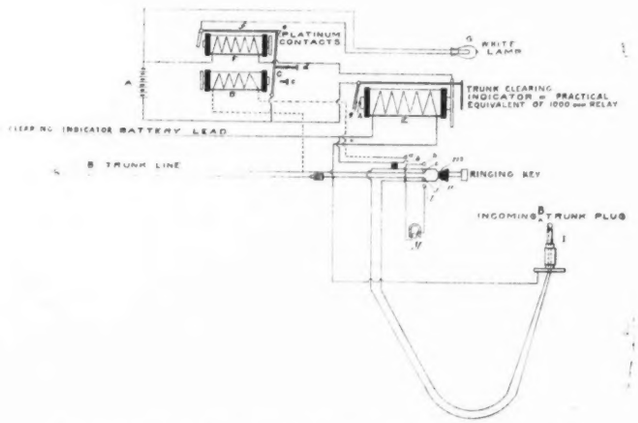

FIG. 8.—THE "EXPRESS" SYSTEM.—DIAGRAM OF "B" OPERATOR'S INDICATORS.

in the "A" trunk will prevent the indicator battery from completing a circuit through any device placed beyond the condenser; hence the indicator current on the "A" trunk does not reach the spring-jacks on the "A" board, but is confined to the "A" trunk and the line and circuits of the calling subscriber. Similarly the indicator circuit of the "B" trunk is entirely independent of everything

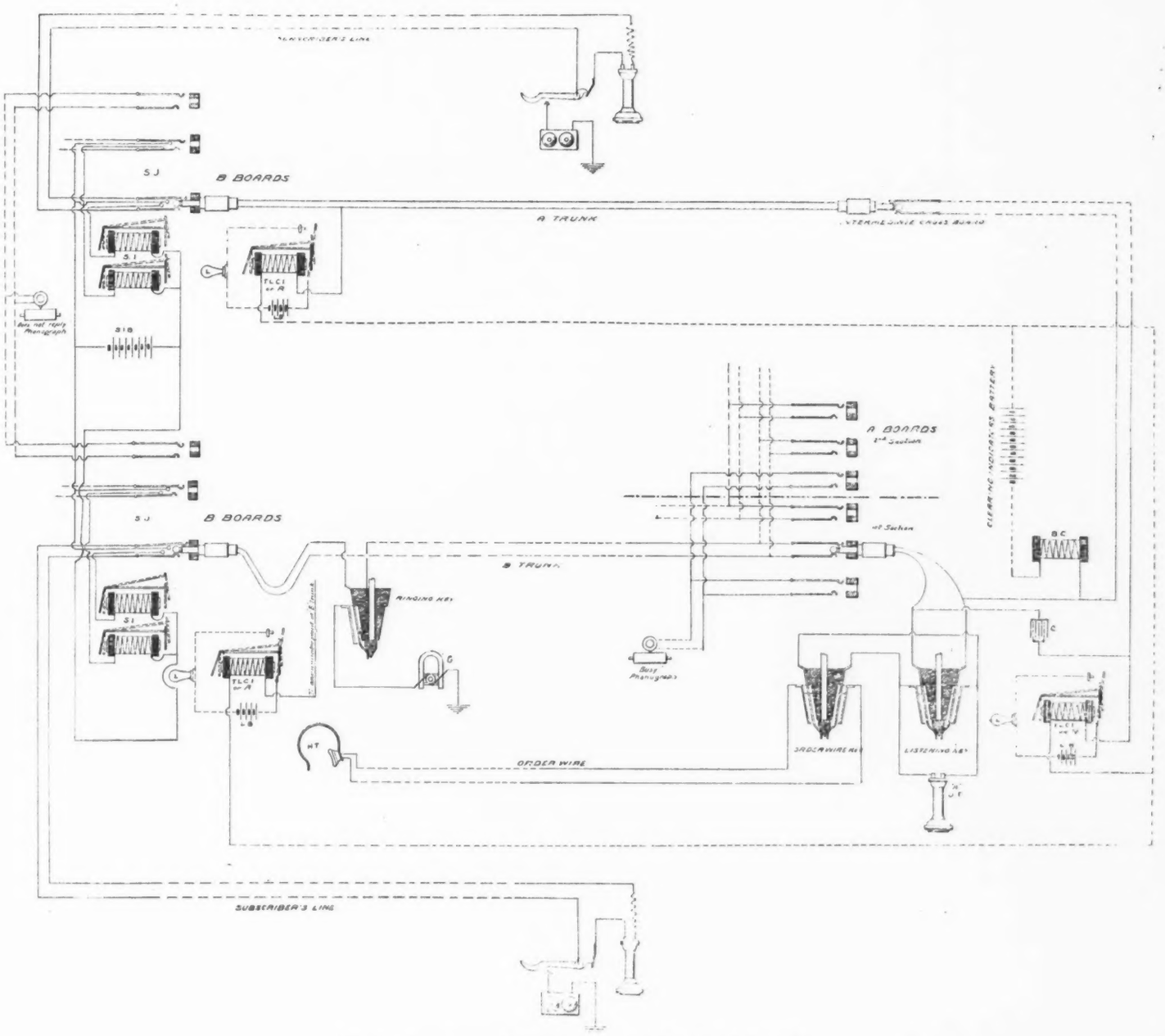

FIG. 9. SIMPLIFIED DIAGRAM OF THE "EXPRESS" SYSTEM.

REFERENCES—T. L. C. I. or "R." Trunk Line Clearing Indicator or Relay.—S. J., Subscriber's Spring-jack.—S. I., Subscriber's Indicators. S. I. B., Subscriber's Indicator Battery.—H. T., Head Telephone.—C., Condenser.—B. C., Balancing Coil.—L. B., Local Battery, "A" O. T., "A" Operator's Telephone.—G., Ringing Generator.

except the "B" equipment. In practice the indicator battery is in closed circuit through the various instruments upon the subscriber's line during conversational use, but as the current is exceedingly small, seldom exceeding one milliampere, its presence is found to be entirely neglected, even in long distance telephoning.

The methods by which the indicator lamps on the table of the "A" switchboard are actuated are clearly set forth on Figure 10, which shows the table complete except the order wire keys, but as the functions and connections of these have been fully explained, and as they cut no figure in the operation of the indicator lamps, the omission is of no consequence. In addition to the order wire keys, the table of the "A" board contains four sets of devices each in a row which are named in order, commencing with the front of the board and individually described as follows:

First are the listening keys, which rest in their normal condition when standing vertically when the operators telephone is cut out of circuit and a secondary contact in circuit with the white indicator lamp is closed.

Second are the white indicator lamps, which are set into the table in the manner shown, and when lighted designate the "A" trunk plug upon which is an unanswered subscriber's call. The battery operating the white lamp may be broken either by the act of a calling subscriber in placing the telephone on the hook, by the "A" operator in lifting the trunk plug containing the subscriber's call from the plug receptacle, or by the "A" operator in depressing the listening key in order to cut her instruments into circuit. In this connection it should be noted that the actuation of indicators whether of annunciator form or miniature lamps invariably occurs

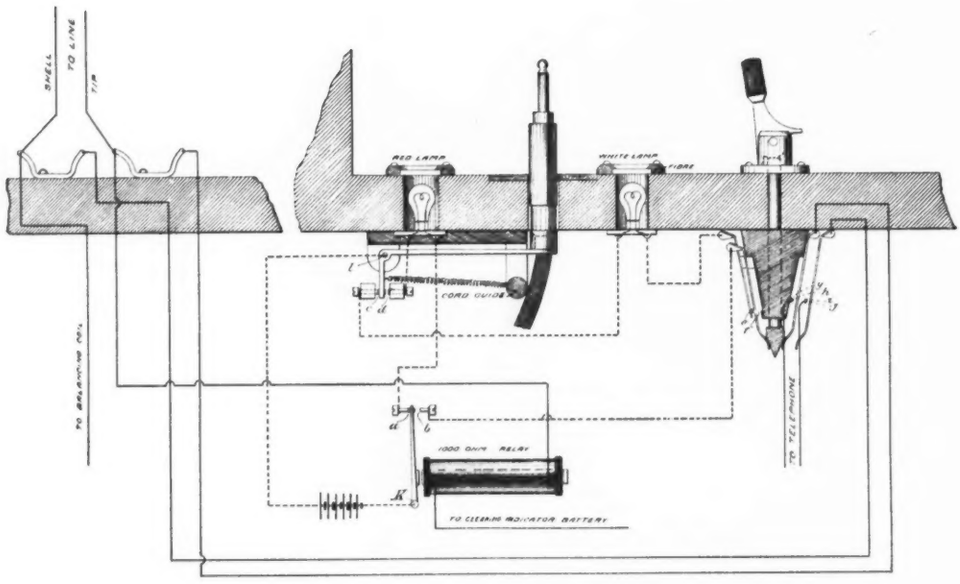

FIG. 10.—THE "EXPRESS" SYSTEM.—TABLE OF "A" SWITCHBOARD, SHOWING THE CIRCUITS CONTROLLING THE INDICATOR LAMPS.

through the performance of a function that is usual in making switch connections, such as the lifting of a trunk plug from its receptacle or the cutting in of an operator's telephone into a subscriber's circuit, etc. In actual work the operation of the white lamp is of a converse nature to that just described: the calling subscriber having lifted the telephone from the hook, sends the subscriber's battery current to the "B" board thus actuating the subscriber's indicator. The operator in charge of the incoming "B" board plugs the "A" trunk line into the subscriber's spring-jack which cuts off the subscriber's battery as previously explained, and at the same time closes the circuit actuating the indicator on the "A" board for that particular trunk through the subscriber's instruments. The indicator circuit being closed lights the white indicator lamp designating a call as stated, and this lamp remains lighted until the call receives attention, when the depressing of the listening key opens the lamp circuit and extinguishes the light. Moreover, should the operator accidentally pull out a busy plug, the returning of such plug to its receptacle would light the white lamp designating it, and so afford instant notification of the error committed.

Then in the third row are the plugs forming the terminals of the "A" trunks which appear behind the white indicator lamps, but their use requires no further description than that already given.

In the last row are the red lamps which form the ringing off or the clearing indicators for the trunk plugs they respectively designate. Like the white lamps, they are, under normal conditions and as described elsewhere, under the control of the calling subscriber so far as their lighting is concerned and also in that they are extinguished when the operator has performed her duty.

Under the table of the "A" switchboard are placed three pieces of accessory apparatus, two of which, the listening key switch and the plug receptacle or gravity switch, are controlled by the operator, while the third is a 1,000-ohm relay energized by removing the subscriber's receiver from the hook and demagnetized by replacing the receiver upon the hook. This relay controls the lighting of the indicator lamps on the table and the operator controls their extinguishing through the ordinary use of the listening key and the trunk plug in switching, as shown. The primary object of the listening key is to cut the operator's instruments into the calling subscriber's circuits, which can be done by drawing the key forward, thereby closing the contacts *g h* and *i j* respectively, which also separates the points *e* and *f*, for the battery circuit for the white lamp. It is plain, then, that if the white lamp is lighted the cutting of the operator's instrument into the calling subscriber's line, as must be done in answering a call, will extinguish the light. The trunk plug rests in and its weight bears down a receptacle forming the long arm of a right angle lever at the fulcrum of which *l*, is connected one side of the lamp battery. The short arm of the lever has two platinum points near the end, which with their respective circuits form the contacts *c* and *d*. When the plug is idle its weight closes the contact *c* in circuit with the white lamp, but when the plug is in use its receptacle is raised by the spring, closing the contact *d* in the red lamp circuit. The red and white lamps are alternately thrown into circuit, but not necessarily operated, by the use or non-use of the trunk plug. The armature of the relay forms one lever of a simple two-point switch, the fulcrum K of which is connected to the other side of the lamp battery while the back contact *a* is in direct connection with one side of the red lamp, and the front contact *b* is in similar connection with the white lamp.

The normal condition of the equipment of the table of the "A" board is as shown in the drawing, and the instant the calling subscriber lifts his receiver from the hook the operator in charge of the incoming "B" board notes the call and plugs it on to the "A" trunk, the other end of which appears as the plug shown in Figure 10. This act on the part of the "B" operator cuts out the subscriber's battery and restores the subscriber's indicator on the "B" board, and simultaneously the indicator battery, being on the "A" trunk as explained elsewhere, is thrown on to the calling subscriber's line, but as this has been closed by the subscriber in taking his receiver off the hook, the indicator circuit is thus completed through the 1,000-ohm relay shown in the drawing. The relay armature springs forward, closing the circuit of the white lamp through the contacts *b e f c*. The light

quickly attracts the attention of the "A" operator, who presses forward the listening key indicated by the burning of the white lamp, and asks "Number." This act opens the circuit of the white lamp at the points *e f*, and cuts in the operator's instruments at the points *g h* and *i j*. Having ascertained the number wanted, the listening key is restored to its vertical position, cutting out the operator's instruments and again cutting in the white lamp. The operator then depresses the proper order wire key, as elsewhere explained, and having ascertained from the outgoing "B" operator the number of the "B" trunk to be used, the "A" operator lifts the plug indicated by the white lamp and inserts it in the spring jack of the "B" trunk designated. The raising of the plug opens contact *c*, which extinguishes the white light, and closes contact *d*, restoring the battery circuit to the wiring of the red lamp, so that when the calling subscriber hangs his receiver on the hook the opening of the indicator battery circuit influences the relay and releases the armature. The contact *a* is thus broken, the contact *b* is closed and the red lamp is lighted, signifying that the conversation is ended and that the lines are ready for clearing. The "A" operator thereupon removes the plug from the "B" trunk spring jack, the plug drops into its receptacle, the red light is extinguished and the circuits are again in normal condition so far as the "A" board is concerned.

X.

It has been shown how, on the incoming "B" board where a subscriber's call originates, the call is made manifest by the dropping of the subscriber's indicator shutter, and how that shutter is automatically restored when the operator plugs the call over on the "A" trunk to the "A" board. It must now be clear how the "A" operator receives both calling and clearing signals, and when it is stated that the clearing signals are made to appear on the incoming "B" board simultaneously with their appearance on the "A" board, through the placing thereon of a relay-indicator wired in multiple with the one-thousand ohm relay on the "A" board, it will be equally clear how the clearing signal on the incoming "B" board is given. The "B" board relay-indicator is the practical equivalent of the one-thousand ohm relay on the "A" board with the exception that it controls only the clearing indicator and therefore has but a single contact point shown as *g*, *h*, in Fig. 8.

The action of the "B" operator's indicator on the outgoing board will be understood by reference to Fig 8. The ringing key contains three sets of contacts by means of which the sides *m n*, of the "B" trunk plug may be thrown in contact at once with the points *i*, *j*, forming the terminals of the "B" trunk, or with the points *k*, *l*, constituting the poles of the magneto M.

In its normal position the ringing key is as shown in the drawing, when the trunk line continues uninterruptedly to the trunk plug, but on throwing the key forward the trunk plug is taken from the trunk line and pressed against the magneto terminals *k*, *l*, which sends the magneto or calling current on the line of the called or outgoing subscriber. Simultaneously with this the ringing key closes the circuit between the points *a*, *b*, which actuates the lower magnet B of the compound relay shown in the drawing and illustrated in Figure 6 as I. The magnet B attracts the armature C from the back stop *c* to its core when the act of the operator in taking the magneto current off the subscriber's line breaks the circuit of the magnet B at the points *a*, *b*, and the armature C falls back closing the lamp circuit at the point *e*. This point is platinum tipped and constitutes the means for the closing of the circuit of the battery A to the white lamp G. The lamp remains burning until the called subscriber takes the receiver off the hook which closes the circuit of the indicator battery as shown elsewhere and actuates the trunk clearing indicator shown. This is the indicator illustrated as D in Fig. 6 and previously referred to as the practical equivalent of the one-thousand ohm relay in use on the "A" board, and it will be noted that when energised its single contact points *g*, *h*, will be closed throwing the local lamp battery A upon the upper magnet *f* of the compound relay, which results in the raising of the lever *f* liberating the armature C and opening the circuit of the white lamp at the ratchet point *e*. It will thus be seen that the "B" operator is fully advised of the condition of the line of the called subscriber even though she has no means of cutting into the circuit and listening to conversations. The lighting of the white lamp indicates the proper transmission of the call to the called subscriber and the subscriber's response thereto is indicated by the extinguishing of the light. The conversation being finished, the called subscriber replaces the receiver

FIG. 11.—THE "EXPRESS" SYSTEM. SUBSCRIBER'S SET COMPLETE.

on its hook thus opening the circuit of the indicator battery and restoring the trunk clearing indicator. The operator being thus informed that the conversation is ended, pulls the plug from its spring-jack which takes the indicator battery off the subscriber's line and places the subscriber's battery thereon, thus restoring the "B" board and the subscriber's line to their normal condition.

XI.

An interesting feature of the "Express" system lies in the use of storage battery exclusively for all exchange purposes and the advantages accruing from this proceedure are most pronounced. How this is done, will be best explained by describing the system as actually

operated by the Pacific Telephone and Telegraph in San Francisco to-day. The telephone system of San Francisco comprises about 5700 subscribers, apportioned between five exchanges, as follows:

Main Exchange.....	3000	Subscribers
East Branch Office.....	800	"
South " "	800	"
West " "	800	"
Mission " "	300	"
TOTAL,	5700	Subscribers

The subscribers of the Main Exchange are handled either through the Main office or through one of its three sub-offices, respectively known as the "Drumm," "Front" and "Grant" sub-offices, and each sub-office contains only "B" equipments that trunk through to the Main office with the same facility and practically under the same conditions that would prevail were they located in the operating room of the same exchange. These five exchanges and three sub-offices, constituting eight offices, are located throughout the city, at distances varying from one to three miles from the main exchange, and are all operated from two sets of storage batteries in the Main Exchange.

Each of these batteries contains eight 150 ampere-hour cells connected in series, one of which known as the subscriber's battery, operates the subscribers' lines and indicators of every telephone in the city, and the other battery, known as the indicator battery, operates all indicators, except subscribers' indicators, in the eight offices named.

As originally installed, the subscribers' and indicator circuits of each "Express" section in San Francisco, were operated from open circuit battery, each such circuit requiring twenty cells, and each such section being independent of all others. Although this arrangement gave no more trouble than ordinarily occurs in the use of open circuit battery, it was not deemed sufficiently satisfactory, and gradually each section of the switchboard was thrown upon the accumulators until now the entire system has been so operated for over eighteen months. The battery circuits are distributed to the various branch and sub-offices by circuits of No. 10 B. & S. bare copper wire supported on poles, and an astonishing feature is that considering all demands including leakage, the output of the subscriber's battery for the entire system of 5700 subscribers varies between one and one-and-one-half amperes, never exceeding two amperes, while the current output of the indicator battery is but five amperes during the hours of heaviest service, all at about 18 volts. The maximum output of these batteries is therefore, but 126 watts, the cost of which compared with the cost of operating the system by open circuit batteries, is insignificant. The service rendered by the accumulators is moreover infinitely superior to that from other batteries.

XII.

Remembering that the permanent terminals of all subscriber's lines are located as individual spring jacks on "B" boards, each subscriber's line having but one such spring jack in the whole exchange, and that the chief functions of each "A" operator are: (1) To ascertain from the calling or incoming subscriber the number of the called or outgoing subscriber and (2) to close the ends of such subscribers' circuits as the "B" operators in charge of the sections containing the permanent spring jacks of the calling and called subscribers respectively, may extend over to her section of the "A" board; and assuming that subscriber No. 409 desires to converse with subscriber No. 1510, the modus operandi of switching in the exchange will be as follows, it being further assumed that both subscribers are located in the same exchange.

The act of the calling subscriber (No. 409) in taking the receiver off the hook will send a call in on the "B" board which will be received on the 400 section and indicated on subscriber's indicator No. 409. The operator in charge of the section says nothing to any one, but extends the line of the calling subscriber over to the "A" switchboard by inserting the plug of an idle "A" trunk into spring jack No. 409. This simple act automatically restores the subscriber's indicator on the "B" board and lights a white indicator lamp on the "A" board designating the particular "A" trunk plugged in and indicating that an unanswered call is thereon. The call being thus transferred to the "A" board, the "B" operator receiving the original annunciation is relieved from listening to the call and from any further effort whatever in completing the switch, unless, perhaps, the called subscriber happens to be on the same section.

The "A" operator presses forward the listening key which cuts her instruments into the "A" trunk designated by the lighting of the white indicator lamp and also into circuit with the calling subscriber whom she asks "Number?" and who replies "1510."

The "A" operator raises the listening key to a vertical position, thereby cutting her instruments out of circuit with the calling subscriber and then depresses the order wire key connecting her instruments with the head telephone of the "B" operator in charge of the 1500 section of the "B" board; that is, the section on which is located the terminal of the lines of the called subscriber.

The "A" operator next calls the number wanted to the outgoing "B" operator in charge of the 1500 section of the "B" board, the conversation between the two operators being carried on over the order wire exclusively, entirely free from the subscriber's circuits. The "B" operator notes that "B" trunk No. 3, for instance, is idle and saying to the "A" operator "On 3," places the plug forming the terminal of "B" trunk No. 3 into the spring jack, forming the terminal of the line of the outgoing subscriber (1510), while simultaneously the "A" operator places the plug forming the terminal of the "A" trunk designated by the burning of the white indicator lamp and on which she has received subscriber No. 409, call into the spring jack forming the terminal of "B" trunk No. 3, thus completing the circuit from the calling subscriber's instrument to the "B" operator of the section of the "B" board upon which terminates the line of the called subscriber.

This completes the switch so far as the "A" operator is concerned as she is not required to supervise the call or to ascertain if the party called for answers. It is upon the outgoing "B" operator that this duty devolves and after having plugged the "B" trunk into the spring-jack forming the terminal of line 1510 which completes the circuit through from the calling subscriber to the called subscriber, the "B" operator depresses the ringing key and throws the magneto or calling current on to the called subscriber's line. This act also lights a white miniature incandescent lamp on the "B" board indicating to the operator that the call has been properly transmitted. When the subscriber responds by raising the receiver from the hook the lamp is extinguished and the clearing indicator is thrown showing that the line is in use. Thus is given positive information as to whether the subscriber has been called and has or has not responded (in which event he will be rung up again) or whether he is using the line. Upon completing the conversation the called subscriber

replaces the telephone on the hook which restores the clearing indicator and informs the outgoing "B" operator that the conversation is finished and that the line may be restored. The operator is thus enabled to determine at any and all times the condition of the line.

The red lamp indicators on the "A" and incoming "B" boards will show for disconnection when the calling subscriber has completed the conversation and replaced his telephone. The plugs of the "A" trunk of both the "A" and "B" boards are then removed from the spring-jacks by the respective operators and are allowed to drop into their sockets, which extinguishes the red lamps. It will thus be seen that the switching of the line of the calling subscriber on to that of a called subscriber requires the momentary attention of the "B" operator; the incoming "B" operator receiving the original call, instantly plugs it over to an "A" operator and gives it no further attention whatever, until the lighting of a red indicator lamp gives notification that the conversation is ended and the plug is to be pulled from its spring-jack. The "A" operator takes the call and transfers it to the outgoing "B" operator in charge of the section on which the called subscriber is located which completes the "A" operator's part of the switching until the burning of the red lamp notifies her that the plug may be withdrawn. The outgoing "B" operator merely closes the final gap between the ends of the subscribers lines and ascertains by visual signals whether or not the called subscriber has responded, which together with removing the plug at the close of the conversation, completes her duty. By this means the work of switching is evenly divided between "A" and "B" operators, and the handling of calls in even the largest exchanges may be done with great facility and perfect satisfaction, with apparatus much less expensive than that ordinarily used.

XIII.

An innovation both practicable and interesting which has been first applied with success in the "Express" system consists in the use of phonographs for the notification of calling subscribers when their calls cannot be answered because of "busy" or of the failure of the called subscriber to respond. In the main exchange are two ordinary office phonographs, the tube of each of which is connected to an individual solid back long distance transmitter by means of the soft rubber tubing ordinarily used in phonograph work, the tubing being centered in a membrane drawn tightly over the mouth-piece of the transmitter. One of these phonographs, known as the "Busy" phonograph, speaks the words "Busy, call again" incessantly, and the other, known as the "No reply" phonograph, says "Subscriber called for does not reply," in an equally industrious manner.

The secondaries of the induction coils for the phonograph transmitters are carried to the sections of the proper switchboards in multiple, that is, the secondary of the "Busy" phonograph appears on each section of the "A" board in the form of a spring jack, and the secondary of the "No reply" phonograph appears on each section of the "B" board also in the form of a spring jack. To illustrate the use of the apparatus: if subscriber No. 409 desires subscriber No. 1510 and the outgoing "B" operator notes that 1510 is busy, she merely says to the "A" operator over the order wire, "busy," and the "A" operator simply inserts the plug forming the terminal of the "A" trunk into the phonograph spring jack. Subscriber No. 409 then hears the words: "Busy, call again," from which he understands that No. 1510 is engaged in conversation elsewhere, and that he is to call up the party again later. He then hangs the receiver on its hook which actuates the indicators and the lines are cleared as at the end of a conversation. The other phonograph throws out the words: "Subscriber called for does not reply," on the calling subscriber's instruments after the outgoing "B" operator finds that she cannot ring up the called subscriber and when she places the plug forming the terminal of the "B" trunk into the phonograph jack. The clearing indicators are then actuated as before.

These two phonographs operate the entire exchange and their use relieves operators from a material amount of labor in conversing with subscribers who soon learn that the phonograph has an exemplary disposition and that "sassing" it is productive of no particular amusement or gain.

There yet remains a feature of the Express system that works great economy in the cost of installing a system by reason of eliminating the necessity of carrying subscribers' lines, whether on aerial or underground circuits, through to the exchange individually. This is accomplished by the establishing of semi-exchanges, known as "sub-offices" in various sections of business districts and terminating subscribers' lines in such sub-offices. Only "B" boards are located at these points, and the "B" operators in sub-offices trunk through to "A" operators in the main exchange over "A" trunks with the same facility and rapidity that they would do were the sub-office "B" boards located in the main exchange. Branch offices differ from sub-offices in that they contain "A" boards as well as "B" boards. They are therefore complete exchanges.

XIV.

The problem of expediting the handling of subscribers' lines in exchanges is tantamount to any presented to the telephone engineer for solution, and the means by which is at once accomplished the greatest facility and satisfaction yet attained in switching, is in the use of the trunking system. This is noteworthy, as trunking has generally, from the earliest days of telephony, been looked upon at best as a necessary evil. The express system is essentially a trunking system throughout, whether installed in main, branch or sub-offices, or whether used between either of these offices, but it is, in reality, an elaboration rather than a modification of trunking in its familiar sense. It seems quite improbable that communication may be established between two subscribers by means of devices requiring the momentary attention and actions of three operators, with more facility than can be done by a single operator upon whose board is found the terminals of the lines of both the calling and called subscribers, and whose practically only act is to loop the lines together. In an abstruse sense this would be an impossibility, but the latent factor which resolves the situation into an established fact rests principally in the training that the telephoning public unconsciously receives from the use of an appliance run on such strict business principles as is the Express system. The subscriber soon learns to respond to the ringing of the bell without a moment's delay, or otherwise he will lose the call, and having done so he is cognizant of the fact that whatever business the calling subscriber had to transact will be lost unless the calling subscriber rings up again. In other words, the policy of the express system is that subscribers must attend to their own business and not rely on central in any manner for reminders of business that has not been attended to.

The extraordinarily favorable results obtained with the Express system, as exhibited in the accompanying plots (Figures 12 and 13), showing the average time of local and trunked connections respectively on the switchboards in No. 1 office, San Francisco, in the Milk-street office, Boston, and in the Cortlandt-street office, New York, graphically portray the various acts that consume time in switching. The plots are so very clear that no detailed explanation of them appears necessary beyond the statement that the Express system is used in San Francisco, while the Boston and New York offices are equipped with modern multiple

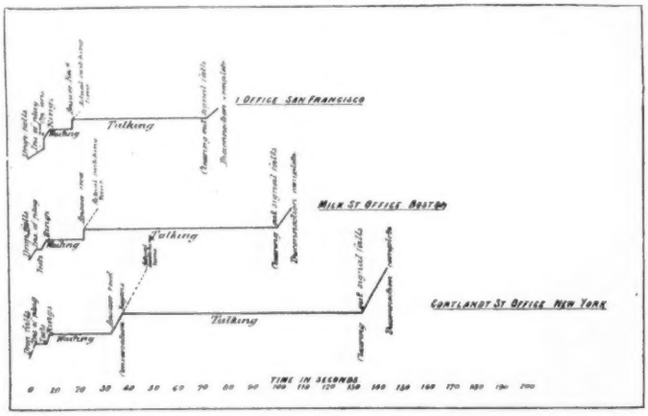

FIG. 12—PLOT SHOWING AVERAGE TIME OF LOCAL CONNECTIONS ON TELEPHONE SWITCHBOARDS—SAN FRANCISCO USING "EXPRESS" BOARDS, AND BOSTON AND NEW YORK USING "MULTIPLE" BOARDS.

boards. The data from which the charts were made was collected by Mr. Theodore Spencer, the well-known telephone engineer of the American Bell Telephone Company, which places their accuracy above question.

It may be well, however, to call attention to a few sapient points that the charts emphasize. As stated, the San Francisco office being equipped on the Express, or essentially trunk system throughout, presents the same record in making local connections as in making trunk connections, but the time consumed in the old form of trunking common to multiple board systems, and as shown in the Boston and New York characteristics, forms a very serious item. The waiting period on the multiple board also considerably exceeds that indicated for San Francisco, which is largely due to the reason given, that when a subscriber on an Express system hears a call he must make it his business to respond. With the multiple system, however, the called subscriber realizing that the calling subscriber does the ringing, will take his time in responding. In brief, a large proportion of the time consumed in switching in multiple systems is due to the slowness and indifference of subscribers in executing the acts that they are expected to and must perform. The advantage held by the Express system in this regard rests, therefore, in the fact that the public has no duty whatever to perform except to remove the receiver from the hook when called and to replace it thereon at the close of the conversation.

A peculiarity of the diagrams is in the different lengths of the talking periods, varying from 54 seconds in San Francisco to 110 seconds in New York, and in this connection a regret may be expressed that similar characteristics are not at hand from Chicago in order that the propriety of that hated charge of "windiness" may be forever settled in the findings of a strictly scientific and unprejudiced investigation.

XV.

The expediency of equipping a telephone exchange with this or that system resolves itself into the old question of commercial practicability—the issue that so unrelentingly condemns the fond but visionary hopes of many inventors. All untried schemes must be considered in the light of ventures, but this article deals with systems that have been demonstrated by hard practical use to be reliable and of commercial utility. Comparisons are not odious when improved conditions result therefrom, hence there is no objection to showing as briefly and as succinctly as is possible, the relative advantages and disadvantages of the two systems that must soon compete for supremacy in the equipment of telephone exchanges, whether large or small. The relative merits of "Multiple" and "Express" systems are as follows:

THE "MULTIPLE" SWITCHBOARD. *Advantages*—1. A single operator completes the entire switching, hence the greatest possible simplicity in working.

Disadvantages—1. Complexity in switchboard wiring; hence

2. Excessive first cost, and

3. Excessive cost of maintenance.

4. Incurs an objectionable increase in the electrostatic capacity of the subscribers' lines because of the enormous amount of switchboard wiring.

5. Injury to a single section by fire, water or otherwise, renders the entire exchange inoperative until repaired.

6. The great number of working contacts creates a serious liability of trouble because of the occurrence of open circuits in the old style board and of short circuits in the new style board.

7. The necessity of applying a manual test for "busy" before a switch can be made.

8. Difficulty of locating switchboard troubles.

9. Excessive cost of making additions, each of which requires not only the adding of a new section, but also the making of additions to the lines of each subscriber entering the exchange.

10. High rates of insurance because of ready susceptibility to damage by fire and water.

THE "EXPRESS" SYSTEM. *Advantages*—1. Low first cost; being not in excess of one-third that of a multiple board of equal capacity.

2. A single terminal for each subscriber, securing absolute simplicity in terminal wiring on the board.

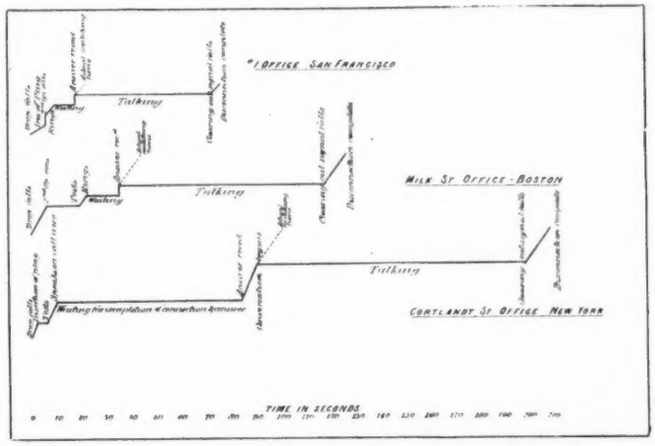

FIG. 13.—PLOT SHOWING AVERAGE TIME OF TRUNKED CONNECTIONS IN TELEPHONE SWITCHBOARDS—SAN FRANCISCO USING "EXPRESS" BOARDS, AND BOSTON AND NEW YORK USING "MULTIPLE" BOARDS.

3. Elimination of the troubles consequent to a great number of working contacts in multiple or in series.

4. Absolute independence of each section from all other sections.

5. Minimum cost of maintenance.

6. Ease of locating switchboard troubles.

7. Automatic visual signals relieve operators from all testing, listening for responses, etc.

8. Impossibility of rendering the whole exchange inoperative because of injury by fire, water or otherwise to a single section; hence

9. Low rates of insurance because of minimum susceptibility to damage by fire or water.

10. Ease and comparative inexpensiveness of making additions, since the cost of a switchboard increases directly with the size.

11. It is an all-trunk system.

12. Highest rapidity yet attained in exchange switching.

13. All signals from subscribers are transmitted automatically, hence with unfailing precision.

14. Enables the establishing of sub-offices, as described, thereby reducing the investment in line wires or underground cables oftimes enormously.

Apparent Disadvantages—1. The services of actually three, and practically two operators are required to complete each switch.

XVI.

The "Express" system has established the fact of its superiority over multiple switchboards, which have hitherto been conceded to be the only means by which the business of large exchanges could be handled to any degree of satisfaction. San Francisco, the home of the system, has tried it long and thoroughly. Electrical engineers whose names are bywords in the world of telephony have visited the city by the Golden Gate that they might themselves examine the system claimed to be superior to the multiple system, yet which had ventured to depart from the lines of construction universally accepted as correct, and having examined it, have been satisfied, and they too confirm its worth. Now Chicago, true to the spirit that has made its name a synonym of progression, is displacing the old method with the new. The telephone world will watch the change with interest, but even so it cannot be said that the "Express" system is in the balance, for it has been weighed and not found wanting.

Educational.

ELECTRICAL ENGINEERING AT THE UNIVERSITY OF CALIFORNIA.

The courses in electrical engineering for the University of California come under the heading of the Department of Mechanical Engineering, of which F. G. Hesse is Professor of Mechanical Engineering, Frederick Slate, B. S., is Professor of Physics, Clarence L. Cory, M. M. E., is Assistant Professor of Mechanical Engineering, L. F. Chesebrough is Instructor in Mechanic Arts and in charge of machine shops, and J. N. Le Conte, M. M. E., is Assistant in Mechanics.

The lectures on electrical engineering are delivered by Professor Cory, and will be upon the following subjects during the academic year of 1895–96:

ELECTRICAL MACHINERY. Construction of electrical batteries and measuring instruments, and their selection for special testing. Discussion of the design and construction of continuous-current electrical machinery; its application to electric lighting and power distribution. Laboratory tests and designing.

ELECTRICAL ENGINEERING.—(*a*) *Alternating Currents and Alternating-Current Machinery.* Theory, generation and applications of single and polyphase alternating currents; effects of self-induction and capacity in circuits; discussion of the construction and design of generators, transformers and other alternating-current apparatus.

(*b*) *Electricity in Engineering and Principles of Electrical Installation.* Discussion of the design, equipment and management of electrical stations; electric lighting, telegraph and telephone circuits; long-distance transmission of power by electricity from water power, and special applications of electricity to industrial purposes.

(*c*) *Electrical Laboratory and Designing.* Practice in the laboratory and draughting-room, illustrating the work of the classroom.

The degree of Electrical Engineer was conferred upon the following graduates of the term just closed: H. W. Corbett, Ch. J. Fox, Olcott Haskell, R. B. Hoffman, J. E. Strachan.

ELECTRICAL ENGINEERING AT STANFORD UNIVERSITY.

Believing that American practice has justified the separation of the Electrical Engineer from the Electrical Manufacturer, and that it has defined the Engineer to be one who is engaged upon the solution of practical problems by the aid of obtainable apparatus, the Electrical Engineering courses of the Leland Stanford Junior University, as shown by the Register for 1894-5, just issued, have been planned for the constructor of engineering work rather than for the manufacturer of machinery. While keeping this aim in view the rapid changes in the profession have not been lost sight of, and the underlying principles of correct design are dwelt upon to such an extent as well fit the Engineer to arrive at just decisions on the merits of established or proposed methods.

The classes in Electrical Engineering are under the instructorship of Prof. F. A. C. Perrine, D. Sc., assisted by Mr. Farmer, and the Undergraduate Courses consist of lectures in (1) Constructive Materials and Machinery, (2) Application and Design, (3) Central Station Design and Management, (4) Engineering Construction, and (5) Recent Applications of Electricity.

Special Graduate Courses will be offered in a series of lectures by Prof. Perrine on (6) Dynamo Machinery Design, (7) The Theory and Practice of the Design of Inductive Apparatus, (8) Telegraphy and Telephony, and (9) Special Applications of Electricity.

Entrance examinations for the next semester begins on Monday, Sept. 2d.

The following class is the first to matriculate the full four years in Electrical Engineering at Stanford: Arthur Hardin Burnett, Tulare; Benson Clare Condit, Riverside; Robinson Crowell, San Francisco; Paul Milton Downing, Palo Alto; Elmer Elsworth Farmer, Palo Alto; Donald Hume Fry, Arcata; Ernest Chesney Hayward, Victoria, B. C.; Walter Spalding Hyde, San Francisco; James Terry Langford, Lodi; Roland Harry Manahan, Pasadena, Maurice William O'Brien, San Jose; Thomas Henry Pomeroy, Oswego, Or.; William Henry Reeves Jr., Seattle, Wash.; Edmund Carmel Southwick, Mayfield; Harry Clinton Thaxter, Palo Alto; John West Thompson, Redwood City; George Lyman Woodworth, Palo Alto.

THE NATIONAL SCHOOL OF ELECTRICITY.

Mr. F. D. Wallaker has recently been appointed Western Agent of the National School of Electricity, with headquarters at Denver, Colorado, where, in a brief time, a class of ninety-five was organized with Mr. Irving Hale as Instructor and Mr. Lewis Searing as Chairman. It is announced that the organization of classes in San Francisco and elsewhere on the Pacific Coast will be commenced at an early date.

The Electrical Journal.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

edited by

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EDITORIAL.

LET ACTIONS SPEAK.

The Electrical Journal is instituted in the belief that the publication of a strictly first class paper, devoted to the industrial applications of electricity, gas and power, will find a welcome and prove a profitable undertaking. It extends no assurances other than of accuracy, independence and impartiality, and knowing that the goal of success it hopes to reach can only be attained through intrinsic worth, it realizes that it will be judged by its works rather than by its promises.

Technical journalism is so done and overdone that the publication of a new paper is regarded, if not with suspicion, at least with wonder. What reason has this journal for existence, and what can it have to say that is worth hearing? It is said of every new venture of the kind that some one has discovered or thinks he has discovered a workable field of patronage. Is it this and nothing more?

But consider the promoters in a more friendly vein for a moment, and it may be that they shall prove themselves worthy of confidence. It is true that all men who are doing the world's work are specialists, and the more each man specializes, the more successful that man becomes. But few indeed can make discoveries or inventions along many lines; nay, even how many are able to study and apply all there is which bears upon one line, or even one point of a single line. The dynamo tender needs the aid of the electrician, the electrician of the physicist, and he in turn must look for assistance to the chemist, the mechanical engineer, the civil engineer, and the manufacturer, as well as to the mathematician and the philosopher. All men's work, therefore, bear upon each man's specialty, and all men must hope to obtain from the journalist the "news" of what the others are doing that they may carry their own work on to its completion. Does any technical journal fulfill this task for its branch completely? We believe not, and judge there yet is room for a new journal, and that new men will have something of service to offer.

The value of a new journal to its readers will depend upon its command of authors capable of telling in an authorative manner of what has been done, and what is doing, and what is to be done. Perhaps the editors may add but little of value to the work of the writers, but the earnest they give is that they will offer the fruits of faithful gleanings from wide fields of experience, investigation and research.

Neither creed or belief then shall receive further discussion, nor shall any hope be expressed but that this venture will merit both confidence and support through the attainment of its aims of honesty and breadth and helpfulness.

ELECTRICAL ENGINEERING ON THE PACIFIC COAST.

Two papers have been read at the informal dinners held by the Pacific Coast members of the American Institute of Electrical Engineers during the past winter which have excited sufficient interest to lead to the belief that in part at least they are worth preserving. The first paper, presented by Dr. F. A. C. Perrine, discussed "The Technical Training of an Electrical Engineer for Practice on the Pacific Coast," and the second on "The Field of Operations of an Electrical Engineer," was delivered by Mr. E. J. Molera. The last named paper, which is reprinted elsewhere in this issue, was designed as a reply to the doubts expressed by a member at the previous meeting as to the usefulness of the many trained engineers now entering the electrical profession, and the writer most completely defines the field of the engineer which makes him truly an engineer and not merely an artisan—a man with skill to build and a foundation to build upon.

Dr. Perrine began by calling attention to the fact that the electrical engineering education in most of the technical schools is aimed to fit a man to be primarily a designer of electro-dynamic machinery or a manufacturer, and little attention is devoted to fitting men for positions when their principal duties consist in the design and erection of engineering works or for acting in the capacity of advisers to choose between the various methods of solving engineering problems. It is left to the future training obtained in the shops of the manufacturing companies to develop these capabilities and there the utmost care is taken that as much of bias for one system shall be given as is possible. Such training leaves the engineering undertakings on the Pacific Coast

at the mercy of the great manufacturers, and indeed the bias given to engineers trained in this manner forms the principal subject of adverse comparison of our electrical engineering with that in England and on the Continent recently made by Mr. H. Ward Leonard.

We have not here the manufacturer of general electrical appliances, nor many shops for repairs or laboratories for the standardization of instruments and the successful engineer amongst us must be trained to be ready with wit and skill to correct all sorts of deficiencies in the apparatus furnished him and to avoid many accidental obstacles. In fact, our needs call for a universality of talents and training which is perhaps impossible to obtain completely except as a born gift, but with the aim of producing the self dependant man and with a knowledge of the material at hand our education must approach their ideal.

The student on the Pacific Coast is, as a rule, a man who depends upon his own resources for support, not only after his years of training, but often before and during these years, and it is rarely that he has received the most complete preliminary instruction. His technical education must, therefore, begin with a most thorough course in mathematics, physics and chemistry, and in later years a choice must be made between the complete study of electro-dynamic machinery and the study of branches more distinctly connected with engineering construction.

With a view to the practical needs of the Pacific Coast engineer it, therefore, seems most wise to educate the men to be as competent critics as is possible of machinery and methods proposed by the manufacturer and to train them at once for the duties of engineer to plan and erect engineering undertakings.

CONCERNING JOURNALISTIC VENERABLENESS.

It is not altogether an uninteresting diversion to see three leading electrical papers chafing over the time-worn moot-point of venerableness, as from information at hand it would appear unquestionable that our esteemed prototype, the Electrical Engineer is really the "oldest" publication as it claims, and that our newsy friend, the Electrical Review, is entitled to the distinction of being the "oldest weekly." As for the "Pioneer" journal, Webster defines the word as expressing "one who goes before to remove obstructions or prepare the way for another," or, in plainer terms, a pioneer is one who steps aside that another may pass on. It is advisable then, if there must be a controversy, that it be confined to the journals named, or the third must either alter its plea or stand convicted on its own evidence.

THE ELECTRICAL JOURNAL rests content in the knowledge that no one can dispute the claim that to-day it stands as the "newest" electrical publication in America, if not in the world, and here again the same authority sapiently defines the word "new" as "recent, fresh, modern."

Clearly then the motto of THE ELECTRICAL JOURNAL shall be: "*The Newest Electrical Publication in America.*"

Literature.

A MANUAL OF TELEPHONY, by William Henry Preece, F. R. S., Engineer-in-Chief and Electrician, General Post Office, and Arthur J. Stubbs, Technical Officer, General Post Office, London, 1893: 508 pages, 8 vo., cloth, fully illustrated. For sale by THE ELECTRICAL JOURNAL. Price, $4.50, post free.

There is perhaps to-day no more up-to-date manual for telephonists than the work which forms the subject of this review, yet this expression of endorsement is not unqualified for in truth no book which has yet appeared contains a full and complete exposition of the workings of the modern, well-equipped telephone exchange of to-day. But this perhaps is not to be hoped for considering the marvellous development in telephone exchanges, and considering that in no country has the handling of subscribers' lines settled down to clear cut, well-defined practices. Preece and Stubbs' work is indeed, more than all others, a manual that will be appreciated by all telephonists, whether in large or small exchanges, and experimenters will find it of historic and practical value. The authors, having had exceptional facilities for investigating the commercial side of telephony, have not hesitated to give a generous share of their experiences to their readers in the shape of circuit diagrams generally drawn to scale, formulae, and such data and specifications as will enable the experimenter to deduce dimensions for the construction of an induction coil giving maximum intensity and clearness of sound in a telephone, for instance. Equally well will it enable the line foreman to effect the greatest possible neutralization of induction by the arrangement of wires on his pole lines, as also will it enable the engineer to determine the capacity of lines under given conditions or on the limiting distance of speech. In brief it forms a universal handbook of telephony, complete to its date. The tendency to favor description of English practices, and particularly that of the British Post Office, is pardonable, but the authors frankly admit their partiality when in the preface they say:

"Telephony, in the broad principles of its practical application, tends increasingly to become cosmopolitan; so that, although English practice generally is more specially described, Continental systems are not excluded, and the principal points of practice in America—the home of the art—are fairly represented."

A conscientious adherence to the idea which seems to have been held by the authors that there is a need for a publication concerning the practical applications of the art of telephony has made the work what it professes and is commended to be, "A Manual of Telephony," more full and complete than any yet published.

THE ELECTRIC CURRENT; HOW PRODUCED AND HOW USED, by R. Mullineux Walmsley, D. Sc. (Lond.), F. R. S. E., etc.: 754 pages, 379 illustrations, 8 vo., cloth. Published by Cassell and Company, Ld., London, and for sale by THE ELECTRICAL JOURNAL. Price, $3.00, post free.

Here is found in a single, handy volume, a reasonably comprehensive exposition of each and every application of the electric current in the service of man, together with descriptions of the various processes by which electrical energy may be produced. The work is divided into three distinct parts, treating of the Production, the Laws and the Applications of the Electric Current, respectively, each of which forms a more than elementary manual of information concerning that portion of the science to which it is devoted. Evidently the author appreciates the fact that readers of electrical literature have had a surfeit of historical matters or descriptions of the phenomena of Electrostatics, for these themes are dismissed after having received such

brief consideration as is reverentially due them in a work of this character. In fact a similar consideration is shown all through the book, and if the author has a hobby in the production, the laws or the applications of the electric current, he has most skillfully concealed it, as his writings bear no evidence of partiality or favoritism to any particular branch or theory. Each is given such consideration as its importance demands. The book cannot be considered as elementary, for it treats of matters beyond the first principles of the science, although first principles are fully expounded, nor can it be classed in the catalogue of advanced treatises on electro-technology: instead it forms a happy medium that deserves popularity, at least because it is a volume that, while not aspiring to encyclopædic proportions, yet contains in clear, concise and simple language an explanation of the basic principles of each and every application or relation of the electric current, whether information is desired concerning chemical reactions, metallurgy, telephony, polyphase transmission of power or even the fire-fly's secret.

ELECTRICITY AS A FIRE HAZARD, by W. J. Jenks. A paper read before the World's Fire Insurance Congress, Chicago, June, 1893. Paper, 73 pages. Published by the General Electric Company, presumably for gratuitous distribution.

In presenting this book to the public the donors have performed a service meriting the appreciation of all who are interested in the common weal. Ordinarily there is so much of the mysterious about electricity in the minds of the public that any successful effort in the way of enlightenment from that unfortunate condition deserves commendation. Such is a characteristic of Mr. Jenks' valuable paper, which is, in reality, a comprehensive review of the technical side of electro-insurance relations during the past sixteen years, freely elaborated with the views of the author. A reasonable inference is that the paper, being published by an electric company, is designed to further the interests of the corporation fathering it, but despite this, the book is free from bias, and presents the various hazards of the applications in a clear lucid way and with profuse colored drawings. It is a book for fire underwriters as well as for electrical men, and its publication cannot but remind insurance interests that their own efforts to restrict the fire hazard of electricity are no more sincere and earnest than are those of the legitimate electrical fraternity.

THE EFFICIENCIES OF ELECTRIC PLANTS.

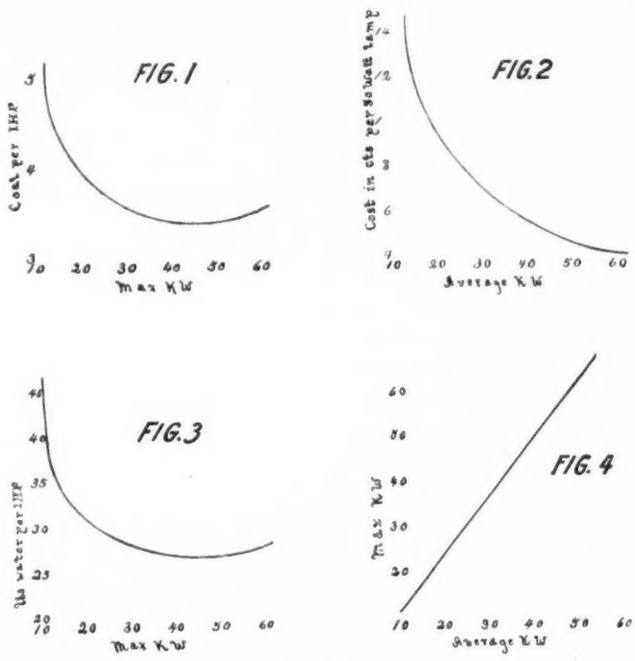
BY SYDNEY SPROUT, E. E., M. E.

I.

Believing that by far too little has been published concerning the economic features of the operation of plants for the generation of electricity, the writer proposes to contribute from time to time as the exigencies of business will permit and as occasion may be presented, such data as may be obtained by actual experiment under actual working conditions, of plants coming under his observation. There will be no effort to make these contributions consecutive for the reasons stated, but the object will be to give *facts* whenever opportunity is presented for unearthing them.

The writer, in investigating a municipal electric lighting plant with the object of ascertaining the actual cost of producing electric energy at various stages of load, compiled the accompanying tables, whence were derived the rough curves also accompanying. Having thus obtained fundamental data it was thought best to go further into the matter than was originally designed, although it has not been the object to go into the finest details of operation, in fact the circumstances of the test would not permit the most minute investigation. Nevertheless the results will be interesting for comparisons that I hope will be brought out during the course of these articles.

The lighting plant herein discussed is equipped with both arc and incandescent dynamos which are about equally divided as to the power required for the operation of each system; consequently the cost of labor is



THE EFFICIENCIES OF ELECTRIC PLANTS.

divided equally between the two systems, or to put it another way, the cost of attendance for the incandescent system is but one-half of what it would be were there only an incandescent machine in the station. This fact not only explains why the item of labor is quite small, but also reduces proportionately several other factors of expense included in the final results.

The equipment consists of two 75 h. p. tubular boilers, two 12x16 automatic high speed simple engines, each rated at 90 h. p. with 240 revolutions per minute and 90 lbs. of steam. These engines were, however, run but to 215 R. P. M. and the engine under consideration is belted direct to a 60-kilowatt alternator supplying commercial circuits, the plant being started in the evening at dusk and shut down at midnight. The other engine is similarly belted to two 60-light arc machines furnishing city street lamps on moonlight schedule.

It may be observed that doubtless many have wondered at the very favorable showing in the way of economy that has been made by some small stations such as this one is, when compared with the larger and better equipped central stations. The results here given for example seem quite low, but when we look at the average load and see that the station is operating under a load factor of 80, while central stations are frequently compelled to run under a load factor as low as 25, the reason for the favorable results herein shown are not difficult to understand.

Returning to the station in hand it will be seen by reference to the curve shown as Fig. 4, that at a maximum load of 60-kilowatts which is not uncommon, the average load is 48-kilowatts, and in the station in question it is found that the cost of producing energy

per 50-watt lamp hour at this stage of load will be $0.0048. On the other hand, in the case of the central station and reducing it to a common ratio, a maximum of 60 kilowatts would bring the average down to but 15-kilowatts which will show the cost per lamp to be three and three-tenths cents per hour. This shows that a station that can run only during the hours of heavy load in the evening, has very great advantages in the way of economical operation over a station that renders continuous service twenty-four hours a day, which is a point that should not be lost sight of by owners of electric plants, whether in isolated or central station work, in their anxiety to deliver to their tenants or patrons a continuous lighting service. It has often been wondered why some small stations equipped with more or less uneconomical apparatus can manage to exist. We know that they do so and that some of them are in apparently healthy condition and offer service during limited hours at prices that well equipped large modern central stations can not afford to meet, but when we consider a station equipped for an output of 40,000 lights and which delivers only about 5000 lights 18 hours out of 24, there is no longer reason for doubting the statements of the central station managers. The station from which was derived the data given, is operated with the highest economy attainable, not only because of the unusual reductions in the items of labor etc., but also because of the fact that the maximum capacity being 60 kilowatts, the average load is 48 kilowatts, which is shown by the water and coal curves to be the most economical point at which the steam plant can be worked.

The results given in the table were obtained by carding the engines at different periods and at different loads, and by actual measurement of the water and coal consumed. The cost of labor etc., represents the actual outlay, and from the data thus derived the remaining results were calculated and checked by means of accepted engineering formulæ.

a	b	c	d	e	f	g	h	i	j	k	l
K. W.	$b=\frac{a}{746}$ E. H. P.	I. H. P.	Lbs. Water Per I. H. P.	$e=\frac{a}{c}$ Watts Per I. H. P.	$f=\frac{d}{7.9}$ Coal Per I. H. P.	$g=\frac{c}{a}\times f$ Coal Per K.W. H.	$h=f\times.288$ Cost of Coal Per I. H. P. hour	$i=g\times.00288$ Cost of Coal Per K. W. Hour.	$j=\frac{3.80}{a}$ Wages Int. and Repairs per K.W. Hour.	$k=i+j$ Total Cost per K. W. Hour.	$l=\frac{k}{20}$ Cost per 50 Watt Lamp
15.4	20.60	35.60	34.00	432	4.30	9.89	1.24	2.85	24.67	27 52	1.380
19.8	26.50	39 60	32.00	500	4.05	8.10	1.17	2.30	19.19	21.49	1.074
24.2	32.40	43.56	30.00	555	3.80	6.84	1.09	1.97	15.70	17.67	.883
25.3	33.90	45.50	29.50	555	3.70	6.62	1.06	1.33	15.07	16.40	.819
28.8	38.60	49.50	28.30	582	3.60	5.61	1.03	1.61	13.19	14.80	.800
35.1	47.00	57.80	27.60	607	3.52	5.77	1.01	1.66	10.82	12.48	.686
39.9	53.58	65.93	27.50	606	3.47	5.61	.99	1.61	9.52	11.54	.577
42.2	56.54	70.29	27.40	600	3.46	5.74	.99	1.65	9.02	11.01	.550
48.8	65.48	83.16	27.00	576	3.41	5.79	.98	1.67	7.79	9.87	.493
52.2	69.79	88.11	27.50	592	3.47	5.76	.99	1.66	7.29	9.42	.471
55.5	74.23	94.04	28.00	590	3.54	5.98	1.02	1.72	6.84	9.30	.434
62.2	81.98	100.98	28.50	621	3.60	5.76	1.04	1.66	6.28	8.36	.418

THE EFFICIENCIES OF ELECTRIC PLANTS.

ON THE FIELD OF OPERATIONS OF AN ELECTRICAL ENGINEER.*

BY E. J. MOLERA, M. A. I. E. E.

It is a law of Nature that all developments shall be done by infinitesimal steps; so that, from the first conception of an idea to its practical application to the needs of man, years of evolution have to pass before the powers that be take hold of it as an acceptable acquisition to the valuable fund of man's possessions.

The electric telegraph as a rapid transmission of intelligence to complement rapid transportation, was the first great application of electricity to the wants of man which demonstrated the great possibilities of that comparatively new resource of his power over Nature.

But not until a few years ago when the economical conversion of mechanic power into electrical energy was effected was it possible to enter into the field of every day's necessities by means of electricity in competition with older methods. The dynamo was employed to produce light and other commercial commodities, and in connection with the telephone, which by a fortunate coincidence was perfected at the same period, created such a confidence to capital that Electricity was a magic word in the world of science as well as in the world of finance.

Then it was when from every profession recruits were drawn to develop the new field of enterprise: the telegraph operator, the mechanical engineer, the manufacturer and technologist, all gave their contingent to the army which was to exploit the new Industrial fields, and they accomplished so many new, rapid and unexpected achievements that the great professors in Electricity were no less astonished than the masses of the people. It was then that the new profession of Electrical Engineering was created.

*Abstract of a paper read at the Informal Dinner of the Pacific Coast members of the American Institute of Electrical Engineers, San Francisco, April 27, 1895.

That imperative call for talent and the splendid success achieved by some of the votaries of the new art created such a rush to supply the demand until now, the former is fully equal to the latter and there is danger of a surfeit of supply. The problem then, today, is how to prevent such undesirable result, by finding new fields of labor for the new comers rather than by discouraging the candidates of the new profession.

The young man fresh from college has unfortunately a great idea of his attainments and consequence and very little knowledge of the stern realities of life. There are few positions good enough for him, and, hearing that there is always room at the top of the ladder, endeavors to reach there with a jump, forgetting that those who were lucky enough to attain that eminence did so step by step, and many times after long and severe struggles.

The sooner he has his conceit knocked out of him the better for his success. He must learn that no amount of explanation will teach a man to swim, and in order to be in it he must obtain perfection with practice. He will find out how easily a man forgets the prescriptions of books and teachers, and how firmly facts are retained when bought at the dear price of experience. Let him understand that success means ability and application. That he must have some of the first and supplement it with the second; that he must acquire method and accuracy in order to obtain thoroughness; that he must work details as carefully as he does the principal parts of his work. He must not disdain little things; and not try to do everything at once:

> Let us be content to work,
> To do the thing we can, and not presume
> To fret because it's little. 'Twill employ
> Seven men, they say, to make a perfect pin.
> Who makes the head consents to miss the point;
> Who makes the point agrees to leave the head;
> And if a man should cry "I want a pin,
> And I must make it straightaway, head and point,"
> His wisdom is not worth the pin he wants.
>
> —Mrs. Browning.

Having the above philosophy in mind, he may enter the field of electrical engineer to give the battle of his life. The avenues are many. As a votary of electricity there is hardly a man's want in which this young daughter of Science cannot be usefully applied, and in which room for improvement cannot be devised. But as his object probably will be of an immediate necessity he can better devote his attention to those departments which are now already organized, and though under the same field are more or less distinct and separate.

He may chose the department of electro-postal engineer, electro-mechanical engineer, electro-municipal engineer, electro-constructing engineer, electro-industrial engineer, electro-consulting engineer, professor of electricity and inventor. Unfortunately the electrical engineer, unlike the lawyer and the physician, does not come in contact with the consumer of the productions of his brain. The nature of the forces in which he deals invites the man of capital to take control of the promising discoveries and pass them through the modern commercial manipulations of corporations and trusts with their shares and bonds, debenture and otherwise, preferred and common stock with paper scattered broadcast to catch the guileless investor. The engineer entering these big engines of trade is appreciated in proportion to his power to bring profits to the company and dividends to the stockholders. Hence the efficiency and real merit of the products of his talent are often ignored and the cheapness and attractiveness of the goods are preferred.

There was a time when the electrical engineer was the constructor and dealer of his own inventions. The houses of Siemens, of Germany and England, Gaspar, of Belgium, Sautter et Lemoinier, Breguet and others of France are conspicuous examples. But to-day the Edison, Thomson-Houston, Westinghouse and other trusts and companies only mean great aggregations of capital used to boom their interests, using the names of those distinguished inventors as money-making means. Sometimes it happens that in order to consummate their financial operations they keep from the public knowledge improvements achieved by the inventors under whose name they operate.

But we are not considering here the evils of modern economy but the field of the electrical engineer.

If he should chose to be employed as electro-postal engineer he will probably engage in the telegraphic or telephonic departments. Perhaps there is no place today more unpopular for an electrical engineer than the telegraph operator, and yet from that department some of the most prominent engineers originated: Edison, Gray, Chandler, Field and so many others. His opportunities to exercise his knowledge will be numerous. The whole range of battery work and different multiplex system will engage his energy, no matter how great it may be. Should he be employed in telephonic work, before him he will see the problems of greatest distance telephony, as well as trans-oceanic transmission, waiting to be solved, and in both departments the utilization of earth currents for means of transmission of intelligence.

Very little need be said of the field of operations of the electro-mechanical engineer. Aside of the amount of knowledge he must use in the proper employment of metal, whether iron or copper, the proportion of the different parts either in dynamos or motors, how much ingenuity is needed in giving a garb to the skeleton of the machine, its stability, its bearing, etc. One only needs to consider the amount of ingenuity exercised in such a simple machine as a bicycle wheel to see the importance of details. What applies to dynamos and motors applies to cars, to lamps, to all other products, electro-forging, welding, stamping, electrical transmission—all are in his field.

I call an electro-municipal engineer an engineer which I consider should exist in every city of importance. In the same way as we have now a County Surveyor, a City Engineer and a Superintendent of Streets, there should be an officer who should represent the city in all matters relating to electricity. The safety of buildings from fire requires that the houses using electric light or power should be properly wired; the same applies to motor-cars. The tracks of electric roads when used, as is usual for return circuits, should be of sufficient size and metallically bonded in their whole length. You have seen from the reports of Messrs. Stuart-Smith and Adams the damages that can be done to the property of other city corporations.

The field of the Municipal Engineer, aside from being the adviser of the city authorities, has under his care the lighting of streets and warming of buildings, the electrical care of the Fire Department, the suburban communication, the under-ground conduits, the distribution of power for small industries. I call electro-constructing engineer the constructor of small electrical machines and measuring apparatus. The essential part of an engineer is the accuracy of his measures; the ultimate object of his work is the best and most economical use of the forces at his command, and for that purpose he must have the greatest assortment and most reliable measuring instruments. No amount of ingenuity and labor are excessive in the designing and construction of such instruments. This department is of such importance that Lord Kelvin has said: "Accurate and minute

measurements seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but rewards of accurate measurements and patient, long-continued labor in the minute sifting of numerical results."

I have given the name of electro-industrial engineer to the one whose energy is devoted to the manufacture of commodities by means of electricity. I might have called it electro-chemical engineer with equal propriety.

Chemistry in modern times has worked a revolution in the production of commodities. What formerly was obtained by man directly from the great laboratory of nature is now in many instances manufactured in the laboratory of man with greater convenience to himself. Foods and beverages; paints and dye-stuffs; metals; materials of construction; fertilizers; medicines; illuminants and articles of all descriptions are prepared by the chemist. It is a remarkable fact that nearly every chemical operation can be done, as far as tried, by electrolytic processes, and in most cases with greater ease and economy. This field of operation is yet in its infancy; the precipitation of all metals from their solutions; the manufacture of chemical products, like chloride of potash, bleaching liquids and caustic soda; the purification of water; disinfecting of sewage; refining of sugar; tanning and many other processes are now already in his field.

The Electro-Consulting Engineer is the one who by original training and subsequent experience is able to advise on any subject in electricity, can design and make plans on the same and superintend the carrying out of them. It is the goal of all young engineers, and none excepting those whose reputation rests on achieved results should undertake this most important branch of Electrical Engineering. His field is every application of electricity and has room to employ every power of his brain every hour of his time and every effort of his energy.

The Professor is born, not made. No amount of learning will make a professor if he has not the faculty of imparting it to others. He must be plain and direct in his statements, patient with his pupils and have that human magnetism which attracts the attention of men and retains their respect and affection. We must remember that the best teaching is by example, and if he besides the above qualities has practically exercised the branches he is to teach, the field of his operations is the most important and the good he does to others of incalculable value.

As a money making pursuit, teaching may not be the most desirable, but the opportunities for scientific research and original work given to the professor in the use of fine instruments and leisure time are full of compensation for other losses. Necessity is the mother of invention. Invention is one of the most uncertain means of satisfying the necessities of the inventor. By the universal law of evolution inventions are developed by degrees so that an invention, we may say, floats in the air before crystalizing into substantial form. It is no wonder that when in the race for glory and profit an inventor reaches the object of his labors, if it be promising of adequate reward, many dispute his claims, and the Government protection, which in many cases protect only the powerful and the wealthy, is put in operation to deprive him of his dues. Under the circumstances a young engineer should not employ his energies in that *ignis fatuus*, but, as many other things, all do it, he must prepare himself well, before entering the grandest and most seductive of all fields of thought. Even after he has mastered the knowledge of many facts and the laws governing them, he may not be rewarded in his efforts to create.

There are some men whose minds are similar to sponges—which will absorb knowledge as sponges do water; but when they bring forth what they have absorbed it comes as it went in, without change or addition to what they first acquired. On the other hand, other minds seem to naturally gather facts, divine laws and force effects spontaneously. Nothing comes to the region of their knowledge without being digested and assimulated to their minds, there to be transformed into new ideas to originate ways and means for the applications of the forces of nature to the wants of man. These are the born inventors. But even they cannot accomplish great things without a good store of facts and knowledge of the laws of Nature.

There are two kinds of inventions: Those new processes of using the laws of nature that fulfill pressing necessities of men and which, on account of their novelty and their extended application, revolutionize existing methods, and those improvements which without changing the existing processes, perfect them. The latter are the most numerous, the best to undertake and generally the most productive. The former are the most difficult and seldom to be undertaken.

In the matter of invention the first thing that the would-be inventor should do is, to establish clearly in his mind the element of the problem before him.

Which are the things that man at the present moment most desires? Are they at the present time already supplied? If so, can they be supplied better and cheaper than they are now? Does the proposed invention imply a theoretical impossibility according to the best knowledge of science at present?

When he has chosen the object of his investigations, then he must acquaint himself with all the processes, if there be any, employed in accomplishing what he wants to improve; and if not, everything similar to it in other branches of science and arts.

Knowing that what he proposes to do would be an improvement on existing methods, that it does not contradict the conservation of energy and in other respects is not a heresy of science, he then can formulate his plan of accomplishing it, in a new and better way, whatever problem he desires to solve.

After that comes the experimental trial; it will propably show him deficiency in knowledge or his error in reasoning. It will instruct him in the best and most lasting way and teach him that whenever practice does not go together with theory the latter must be wrong.

Electricity and magnetism have been the last of the forces of Nature utilized by man for his wants.

The reasons are obvious: The most precious things for the existence of man Nature has abundantly supplied: Few minutes without air would kill any mortal; Nature supplies it to him in unlimited quantities at every place without the least effort on his part. Few hours without water would be quite uncomfortable for any one, and Nature again supplies it very abundantly, though he has some time to store it, or has to have some one to bring it to him and pay for it.

He could not subsist without food many days, and though he has to gather it, or cultivate it, still it is easily obtained by him.

Heat is the next requirement and is sufficiently stored in our atmosphere to keep him comfortably in many parts of world and in the others shelter and fuel can also be acquired without great difficulty.

Light is not of such vital importance, and for that reason one half of man's life is kept in darkness.

Man is a most wonderful organism and yet as a testing organism is most imperfect, As a dynamometer,

thermometer, phonometer he is poorly good. A photographic plate can register the impressions of more points of light, say stars, with a simple lens, than man can perceive with the Lick refractor. As an electrometer, whether Ampere or Volt-meter, he is a dead failure.

From creation the paternal sun has been throwing myriads of waves of electricity and magnetism and man was innocent of the existence of either of these forces. It took the genius of the great scientists of the beginning of this century to know something of their nature and make them manifest at their will. Not until half of the century had elapsed, was it found that they were correlatives of heat and light. The century is closing and we only now find out that the same laws of emission, radiation, reflection, etc., that obtain in heat and light, apply equally as well to electricty and magnetism.

Maxwell pointed out the propagation of the electromagnetic wave through ethereal space: Hertz has demonstrated by means of his oscilator and reasonator the existence of such waves and has measured the time and size of their oscillations, and together with Tesla, Thomson and others have demonstrated the other points of resemblance to the laws of light.

It is in this direction and the thorough knowledge of these facts and theories that will bring forth the greatest number of inventions in Electro-magnetism.

The main departments in which Electricity may be used is as power to overcome gravity, energy to produce heat and light, and as means to promote chemical reactions.

In the shape of evaporation and condensation of the vapor of water and in the heating of the air, we have now two valuable sources of power, viz.: water and wind power. It is known that the potentiality of the atmospheric electricity changes with the distance from the earth's surface and with time. The earth itself is a great magnet, with magneto-electric currents constantly flowing from the equator to the poles. The deviation of the needle and the glow of the aurora clearly show it. Even supposing that its rotation in the ether produces no friction whatever, the great surface velocity at the equator, which is more than 90,000 feet per minute, would in presence of the magnetism of the sun produce great earth currents. Now, do such currents store themselves, as light and heat do in vegetation and the coal measures, or, in some unaccounted way, dissipate through space?

I will not touch the many unsolved problems of light without heat, great heat without combustion, and possibly without light, transmission without metallic conductors, and seeing at a great distance by electrical means. I will come back to the point of beginning—how the opportunities of a young engineer may be improved.

First, by his being prepared to meet the new and increasing demands of electrical application. In the coming wedding of electricity to all the other branches of industries, are the civil and mechanical engineers to acquaint themselves with electrical knowledge to build and operate the future electrical railroads? Is the metallurgist to become an electrician or the latter a metallurgist? Is the chemist to study the properties and effects of the electric current, or the electrician the reactions that follow the combination of the elements of matter in certain proportions and in certain ways?

Electricity is the younger science, is the growing one; it should be enterprising and dispute the field of operations wherever there is an opportunity.

The electrical engineer should now take a stand for his rights, should unite his individual efforts to those of his colleagues and be willing, even if he be at the top of his profession, to stand in with his brother engineers. They all together should teach to the trust, to the corporation and to the citizen, that it is equally as absurd to devise plants for manufacture and stations and to run them without competent and well-remunerated engineers, as it is to build roads without surveys or build houses without architects; that it is equally as absurd to leave the wiring of houses to the contractor as it would the plumbing to the plumber. That it pays to investigate whether or not the cheaper is the best, and that money spent in paying well the conscientious engineer is the best of all economy.

Historical.

THE COLUMBIA'S PLANT DISMANTLED.

After the present month the interest which the veterans of incandescent electric lighting have always felt in the Oregon Railway and Navigation Company's steamship Columbia, will fade, for that vessel is now on the dry-dock at the Union Iron Works, in San Francisco, being entirely reconstructed and its venerable electric lighting plant, which was not only the first ever placed on any vessel in the world, but was also the first plant installed for commercial purposes and placed in the hands of outside parties for operation by the original Edison Electric Light Company, has been torn out and will be replaced by modern apparatus. The history of this most interesting installation has been described heretofore,* but now that the equipment has ceased its practical usefulness it is meet that the event should be recorded.

The credit for conceiving the installation of incandescent lamps on shipboard appears to be due to Mr. Henry Villard, then President of the O. R. & N. Co. and the Northern Pacific Railway Co., a Director in the Edison Electric Light Co. and an intimate friend of Mr. Edison. This was in 1879, when the Columbia was being built at the Cramps' Shipyard, in Chester, Pa., and orders were given that the vessel should be equipped with incandescent lights. At the suggestion of Mr. Edison Mr. J. C. Henderson, then advising engineer of the O. R. & N. Co. and now prominent on the engineering staff of the General Electric Company, was placed in charge of the installation, and that he did his work well, even though in a manner that now bespeaks the crudity of the state of the art of incandescent installation at that time, is evinced in the fact that the plant has a record of service for a period of nearly a quarter of a million hours with no repairs to the machines, it is said, except the rewinding of one field coil, and a few minor repairs to the bearings, etc. So far as can be ascertained the Columbia never lost an armature, and the commutators have received only such attention and renewals as has been necessary from normal and proper usage.

The Columbia's plant consisted of four Edison long field core dynamos of the original type now known as the "Z" pattern. The capacity of each of these machines was 60 16-c. p. lamps, but as only three of them were used for lighting service, the third being utilized as an exciter for the remaining three, the total output of the plant was 180 lights. The vessel was wired for 115 lamps, placed in the cabins and staterooms, but regardless of this fact when the vessel was at sea the four dy-

* Electrical Engineer (N. Y.), Vol. XV, No. 252, March 1, 1894.

namos were operated continuously from dark until 10:30 o'clock each night during the fifteen years the plant has been in operation. The plant was installed in the early part of 1880, and on the 2d of May in that year the dynamos were first started.

In the light of present practices and beliefs it seems impossible that the wiring of this pioneer equipment should have been in use for fifteen years on shipboard exposed to dampness and other possibilities of injury

Relics of the First Marine Incandescent Installation.

without having caused serious trouble, but despite this the No. 11 cotton-covered paraffined wire, which was used for the mains, and the No. 32 cotton-covered paraffined magnet wires used for the branches, all being stapled to the wood work and painted over, remained in serviceable condition to the last. It is stated, however, that originally the plant was installed without fusible cutouts, and that the necessity for cutting off the current by some means upon the occurrence of any abnormal condition in the circuit such as would be occasioned by short circuit, leakage, etc., was impressed by earlier experiences with this plant, and that before leaving for her trip around Cape Horn, the Columbia's lighting plant was provided with safety fuses in the mains near the dynamos and in each lamp socket or at each lamp. All mains and lamp circuits were bunched together, and the main bus wires from the dynamos to the switchboard, or more properly speaking, to the fuseboard, were of bare copper wire stranded and inclosed in a soft rubber tubing, each bus having a strand for each circuit controlled from the fuseboard. The dynamos were driven from a countershaft driven in turn by a pair of high-pressure vertical engines. The countershaft, which was directly over the dynamos, was run along the aftward wall of the main engine room, and the arrangement of belting between the engines and the dynamos through the countershaft was at a very high angle, in order to economize freight space. A further peculiarity rested in the fact that the armature of the exciter was driven at half the speed of the armature of the lighting machines.

The difficulties attending the first installation of incandescent lighting could be made very clear by an examination of the Columbia's plant. The first lot of lamps installed were of the paper carbon variety, which were so delicate that it was soon found that the jar of the ship's engines broke the filaments at an alarming rate, to overcome which, the lamps were fitted into small turned wood bases and suspended by strips of felt ribbon. Later wood receptacles were used that were placed flat against the surfaces of the ceilings but seperated therefrom by light thick felting to minimize the jar. The sockets wherever used were of complicated type mounted entirely in wood, but the staterooms were lighted by means of lamps mounted on receptacles or the small wood bases described and completely enclosed in ground glass globes so as to be beyond the reach of passengers. These lights could be controlled only by a wooden switch located outside of the stateroom and turned on and off by a key in the hands of the steward. It was necessary, therefore, to ring a call bell and await the response of a steward before the lamp could be lighted or extinguished, and often then it would be necessary to resort to the use of the oil lamp, because of the fact that the regulation of dynamos was such that they could not control the potential under material changes in load. Parts of the lighting apparatus here described are shown in the accompanying illustration.

The incandescent electric lighting plant on the Columbia proved a source of wonderment, not only on the Pacific Coast, but at every port at which the vessel stopped on her voyage around the Horn. Through Mr. Villard's association with Mr. Edison's and the O. R. & N. Co.'s interests, it was arranged that the vessel should stop at every principal port and give exhibitions of the apparatus. The engineers of the Columbia who have been with the vessel from the time it was built, state that the lamps of the paper carbon variety did not outlast much of the trip to the Pacific Coast, and that the replacing of burned out lamps became monotinously frequent. Upon arriving on the Coast, however, a new lot of lamps was received from the East, in which bamboo filaments were used; these gave much better satisfaction and many of them, it is stated, have a record of 5000 hours, while some have burned 9000 hours, and a very few lamps that were seldom used were still connected on the circuits when the plant was dismantled.

In addition to the incandescent plant, the Columbia was provided with a 2000 c. p. power search light operated by a small Siemens' vertical type dynamo with von Hefner Alteneck drum armature. The vessel, when refitted, will be provided with a 400-light Siemens'-Halske generator, direct connected to a triple expansion marine type Union Iron Works engine.

THE HEART AS A PUMPING ENGINE.

Poets and philosophers are fond of marveling at the wonders of the human heart, but they usually confine themselves to homilies on its ceaseless activity, and some of the things that are most wonderful of all escape their attention entirely. One of the most remarkable things about the heart is the amount of work it does. Considering the organ as a pump, the task of which is to deliver a known quantity of blood against a known "head," it is easy to show that in twenty-four hours a man's heart does about 124 foot-tons of work. "In other words," says a contemporary, "if the whole force expended by the heart in twenty-four hours were gathered into one huge stroke, such a power would lift 124 tons one foot from the ground. A similar calculation has been made respecting the amount of work expended by the muscles involved in breathing. In twenty-four hours these muscles do about 21 foot-tons of work.

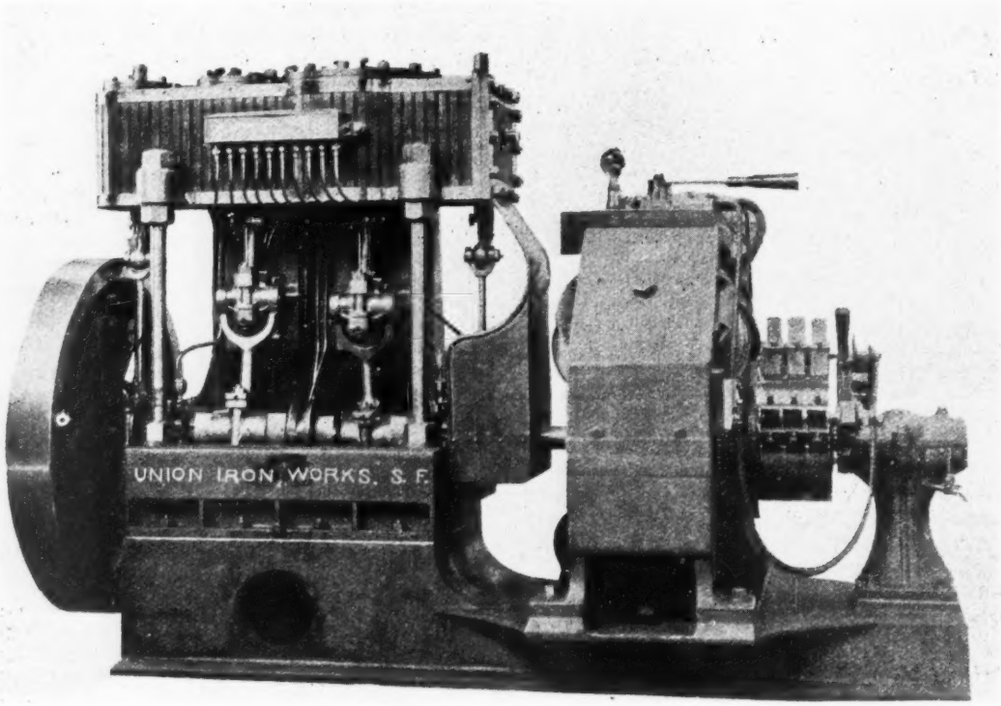
Recent Installations.

ELECTRICITY ON THE CRUISER OLYMPIA.

By W. W. Hanscom, M. E., E. E.

The electrical equipment of the new United States cruiser "Olympia" recently finished by the Union Iron Works of San Francisco, represents a very complete and modern marine plant in every way, and the extent to which electricity enters into the handling of vessels of the new navy could not be more fully expressed than by giving a description of the installation and its various functions. To facilitate description therefore, the various parts of the plant are considered under the following sections:

The Generating Sets, consisting of combined engine and dynamo, directly connected and mounted on a single bed plate as shown in the accompanying illustration,



Electricity on the Cruiser Olympia.

are four in number, each having an output of sixteen kilowatts and forming at once a complete and independent set.

The Engines are of the Union Iron Works standard, compound condensing inverted cylinder vertical type developing at four hundred revolutions, twenty-six indicated horse power. An auotmatic governor of the Ide type controls the admission of steam into the high pressure cylinder by acting directly on its valve and so perfect is its action that the variation in speed from no load to full load and reverse is only three revolutions or $\frac{3}{4}$ of 1 per cent.

General Electric Compound Wound direct current four pole marine type generators of eighty volts and two hundred amperes are used each machine being directly connected to its engine. The windings are so proportioned that the voltage varies but $1\frac{1}{2}$ volts from the normal between no load and full load. The armatures are gramme rings with windings of ample capacity to carry an over load of 50 per cent to 75 per cent without injury and when operated under full load for four continuous hours heat 49° F. above the surrounding atmosphere. The commutators are large in diameter and present a large bearing surface for the brushes and are cross connected at 90° requiring but one set of negative and positive brushes.

One of the most interesting features of the installation is the switchboard, which is of slate and designed for eighteen circuits operated by four dynamos. The bus bars and switches are arranged to permit either dynamo to be used separately on arc, incandescent or motor circuits, or for all dynamos to be operated in parallel on all circuits also in parallel. Instrument boards, placed on each side of the main switchboard carry independent Weston voltmeters and amperemeters for each dynamo and search light and also the ground detector. A valuable feature of the switches is the fact that the switch blades are removable when not in use, which reduces the possibility of careless switching.

The wiring is installed under the two wire system, each pair of conductors being carried in wooden moulding with all joints in mains and for branches made in water tight bronze junction boxes; the wires entering through packing or stuffing tubes made tight by soft rubber glands. Where led through bulkheads, the wires pass through water tight stuffing tubes made so in the same manner. The circuits are divided into lighting and battle mains, the former for general illumination and the latter for use in time of action. No single wire larger than 16 B. W. G. is used, larger sizes being stranded to give the required area. The insulation of the wires is as follows: 1st A layer of pure Para rubber 2nd A layer of vulcanized rubber containing about 50 percent sulphur and lastly a layer of woven or braided cotton, saturated with a flame and moisture-proof compound. The average resistance of each outlet to ground including wires, junction boxes and switches and dynamos, after a year's installation and use was sixty million ohms.

The fixtures are all designed with special reference to their respective uses and are finished in dark bronze or oxidized silver according to location. Ceiling rings,

steam tight globes, desk lights and bulkhead fixtures for officers' and crew's quarters, living spaces, engine rooms, passages, etc. together with coal bunker lights, magazine lanterns and brackets, besides water tight switches and receptacles and plain receptacles, are designed with a view to continuous service.

Motors are used for ventlation and ammunition hoisting, the ventilating motors, three in number being arranged as follows: One, a 2 h. p, motor is located in the dynamo room and keeps it supplied with cool air drawn from above the decks. The other two of ¼ horse power each, are portables, being arranged to be carried about and used for ventilating coal bunkers, double bottoms, etc. Each motor is fastened to the side of and directly connected to the fan of its respective blower. Three eight horse power shunt wound water proof motors are located in the passing rooms and used for hoisting ammunition to the gun deck for the 5-inch broadside guns, while two five horse power series wound motors with reversing rheostats are located in the turrets and keep the eight inch guns supplied with ammunition

The signaling equipment known as the Electric Night Signaling apparatus consists of a series of double lanterns, the upper halves red and the lower halves white, fastened one above the other on a stay of the main mast; a 32 c. p. lamp in each half is connected to a key board located on the after bridge. Numerous combinations can be made by revolving a handle over an index plate on top of the stand. A truck light, similar in design to the signal lantern is located on top of each mast and connected to and operated by switches on the forward bridge.

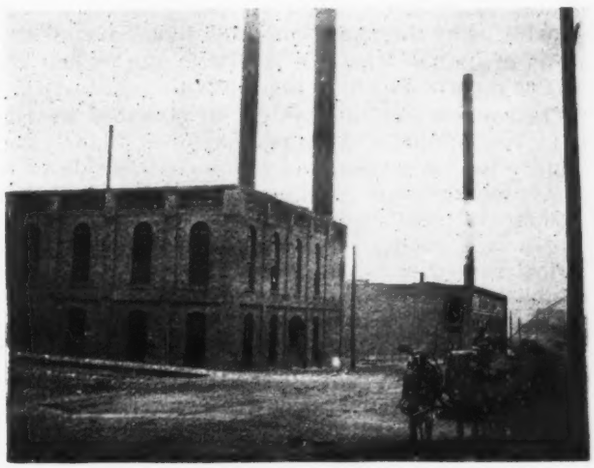
Four Mangin projectors, 30 inches in diameter, are located on the fore and main tops and on the broadsides. These lamps require one hundred amperes each at forty-five to forty-eight volts, the reduction from eighty at the dynamos being accomplished by means of a dead resistance in series with the lamps. Each projector is furnished with two lenses, the inner one forming a hinged door in front of the projector, and the outer one, operated from the back, slides in front of the inner one changing the rays from a parallel beam of great intensity to a diverged or fan-shaped one of more area but less intensity. The lamps, which are arranged for either hand or automatic feed, are so proportioned as to keep the arc always in the focus of the mirror in back. A damper allows of shutting off of the light from the mirror, thus permitting intermittent flashes of light to be used for signaling. The two broadside projectors are, by means of motors and gearing in their bases, controlled electrically by a controlling device in a further part of the ship and can be revolved, elevated or depressed at will. The candle power of the beam is rated at 100,000.

The alarm system consists of hinged floats containing mercurial contacts, located in each water tight compartment and so arranged as to close a circuit when water has found its way to and capsized them. The closing of the circuit operates an annunciator on the main deck, notifying the officers of the location of the trouble. Thermostats in each coal bunker are arranged to give a similiar alarm upon the temerature in any of them rising above 200° F. Electro-mechanical gongs located in numerous parts of the ship and operated by contact-makers similar to a fire alarm box, are used for calling the crew to quarters in case of fire or other reasons.

Interior communication is effected through the use of the push button and annunciator systems and telephones. Calls can be made from one-hundred seventy different points all over the ship and the telephones offer a ready means of communication between the Captain and Chart House, and the turrets and passing rooms and central station. The transmitters are regular granular Hunnings type and are connected in series with the battery, the receivers being used without induction coils. An idea of the completeness of the various systems of interior communication may be had from the fact that it required over 70,000 feet of insulated copper wire or nearly 13½ miles, to make the wiring connections.

A SEATTLE ELECTRIC STATION BURNED.

The electric power station and car barn of the Seattle (Wash.) Consolidated Street Railway Company was destroyed by fire early on the morning of June 20th, causing a loss, roughly estimated, at $100,000. The building was a substantial brick structure, 60 feet by 260 feet in area, occupying the entire side of the block on the north side of Pine street, between Fifth and Sixth streets, and was so constructed on a hillside that the main floor, constituting the car house and repair shop, was on a level with Fifth street, while the basement floor, on which was located the boiler and



engine and dynamo room, was on a level with Sixth street. The photograph from which the accompanying half-tone was made shows the northwest corner of the building, containing the boiler room on the lower floor and the repair shop on the upper floor.

The plant equipment consisted of the necessary boilers and two Corliss engines, each rated at 225 horse-power, either or both of which operated a counter-shaft, driving the six Thomson-Houston type D62 railway generators which the station contained. The building is reported to be completely gutted and in addition to the building and plant the company lost twenty-five cars that were in the building at the time of the fire. An insurance of $40,000 was carried.

The building represented in the foreground of the illustration is the burned station of the "Seattle Consolidated," while that in the background is the lighting station of the Home Electric Company, now consolidated with the Union Electric Company of Seattle.

ELECTRICAL INSPECTION IS NO MORE.

Every employee of the Board of Fire Underwriters of the Pacific except one — Mr. E. F. Mohrhardt, Secretary of the board, has received his demit to take effect June 30th, and only the barren organization will hereafter remain until such time as it may be deemed advisable to adjourn *sine die*, or to reorganize.

Underwriters' electrical inspection in the nine States and Territories of the Pacific Coast is, therefore, a thing of the past, but it is being carried on in San Francisco through the Underwriters' Inspection Bureau.

Electro-Insurance.

LIGHTING FROM TROLLEY CIRCUITS.

The Underwriters' Electrical Bureau of Chicago, acting for the Underwriters' National Electric Association, has just issued Electrical Fire Hazard Pamphlet No. 3, discussing the hazards of operating lamps and motors by current supplied from electric railways using the grounded trolley system and which is supplemented by letters from many of the principal independent electrical engineers of the country substantiating Rule 41 of the National Code, which reads:

LIGHTING AND POWER FROM RAILWAY WIRES.—Must not be permitted, under any pretense, in the same circuit with trolley wires with a ground return.

The pamphlet points out that this rule was framed by the Electrical Committee of the Underwriters' National Electric Association, and *represents the unanimous opinion of the electrical inspectors of the United States*, and that its enforcement is necessary for the general good as is demonstrated by the numerous fires that have occurred because of its violation, as shown in the various electrical fire reports issued by the Bureau.

The reasons why this system of electrical distribution is far inferior and more hazardous than systems ordinarily used are stated as follows: One side of the circuit is normally grounded, which means that but *one* accidental electrical connection between any part of the wiring and a conducting substance of any nature in electrical connection with the earth, is necessary in order to establish current flow and a resulting "burn out" or fire.

In a complete metallic circuit, *two* such connections are necessary before current flow can be established, and, therefore, the grounded system is considerably more than twice as hazardous as the metallic. The wires of a trolley road being run overhead are susceptible to lightning discharges, and a line being run into a building to a motor and then into the earth, affords an easy, convenient and oftentimes preferable path for the discharge to travel, setting fire to the property on the way. The voltage or "pressure" used on trolley systems is sufficiently high (500 volts) to be classed as a "high potential" under the rules, and the energy used on the circuit is sufficient to necessitate the generation of current quantities frequently great enough to produce very severe heating effects, thus entailing the disadvantages of the series arc system in the comparatively high voltage used, coupled with the disadvantage of the low potential system, which uses large currents, and this results in bringing about enormous heating effects at the point where the break occurs. This is a very hard form of energy to properly control even under favorable circumstances and when traveling over the uncertain path offered by a grounded trolley system, it cannot be considered desirable or safe for introduction inside of buildings. Lightning arresters, extra insulated wire run on large size glass insulators, special fuses, double mounting of the motor, grounding outside the building, a sign reading "danger," a voltage reducer and numberless other proposed safeguards, are advantageous, and each does its little to decrease the probability of trouble, but they cannot make a grounded circuit the equivalent of a metallic circuit from any point of view.

The electrical engineers who contribute letters condemning the practice in question are Messrs. Pierce & Richardson, J. P. Barrett, Wm. A. Anthony, Stone & Webster, W. M. Stine, Wm. L. Puffer, E. P. Roberts and L. K. Comstock.

ELECTRO-CHLORINATION.

A new process for the extraction of gold at a very small expense is soon to be started at the Gold & Globe Mill of the Cripple Creek (Colo.) Gold Milling Company. The method to be used is known as the "Electro-Chlorination Process," and although certain parts of it are held secret, it is known that the idea is based on the passing of a heavy current at low potential through crushed ore immersed in a solution of sodium chloride. The sodium and chlorine are separated under the action of the current, the chlorine uniting with the gold, forming a chloride of gold which is deposited on a sheet of lead or other suitable cathode.

The deposition vat will consist of a large tank, the bottom of which is to be lined with blocks of carbon to a thickness of about three inches. Above these carbon blocks, which form anodes, will be spread the ore crushed to about a sixty mesh, upon which is poured the solution of sodium chloride, and on the surface of the liquid is supported the cathode. The dynamo used will have an output of 6,000 amperes at 20 volts, and it is claimed that on ton lot experiments, 94 per cent. extractions have been made in 45 minutes. The secret part of the process consists in the use of an ingredient which, when added to the sodium chloride solution prevents the liberated sodium from re-uniting with the chlorine

All experiments have hitherto been carried on in Philadelphia, and having proven successful, a full equipment has been manufactured and the machinery is now in process of erection at Cripple Creek.

THE CHICAGO RAIL BOND.

The consolidation of practically all of the street railway interests of San Francisco and the conclusion of the Market Street Railway Company thus formed to equip all lines so far as practicable with electric traction naturally led to the organization of an electro-technical department in the charge of men of undoubted experience and ability in electric railway construction. Of all the apparently "little" details of equipment that have come under the consideration of this department none have been given greater care and attention than that bestowed upon the all-important matter of rail-bonding.

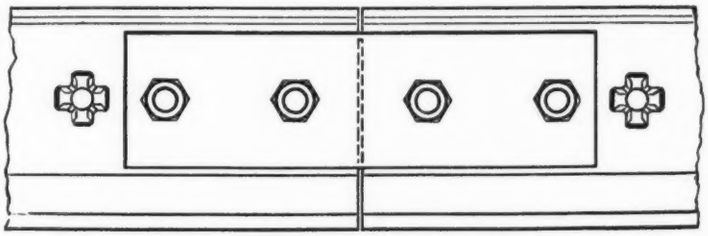


FIG. 1.—THE CHICAGO RAIL BOND.

In the earlier construction of electric railways the engineer made all his estimates and calculations with the utmost accuracy and scientific precision for the overhead half of the circuit, and spared neither money, time, labor nor copper to bring that half up to the highest standard of perfection; but the practical results which he aimed to attain, namely, a low percentage of loss or drop upon the line, and economical consumption of coal at the power house was seldom, if ever, realized, because he neglected to complete the metallic circuit by properly bonding the rails together at the joints. The energy losses occurring through defective bonding soon were realized to form an abnormally high factor in the total

losses in the operation of electric railways, to obviate which has been the study of the ablest electric railway engineers.

After mature consideration of all systems of rail-bonding yet devised, the Market Street Railway Company adopted the form shown diagramatically in the accompanying sketches and which is known as the "Chicago" rail bond. In this the rail bond proper, C, is a copper rod or wire having tubular or thimble-shaped terminals which are bent at right angles to the bond, and with its two tubular terminals is composed of one solid piece of rolled copper. The tubular or thimble-shaped terminals, A, are inserted into holes through the web of the rail, *a*, and the slitted end of the terminal, A, is spread or clinched over on the rail with a hammer and

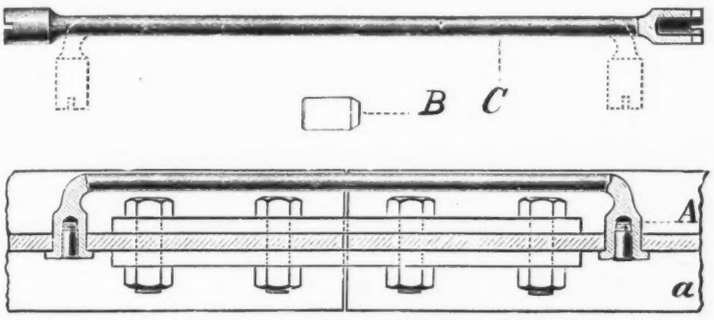


FIG. 2.—CHICAGO RAIL BOND.

punch; this holds it from drawing back out of the hole. The drift pin, B, which is larger than the opening in the tubular or thimble-shaped terminal, A, is then driven into said terminal, thus expanding it and wedging it into solid contact with the surface of said hole through the web of the rail, *a*, making an absolutely solid joint from which every particle of air and moisture is excluded and which experience has thus far shown to be proof against corrosion or electrolysis. The "Chicago" rail bond has therefore been adopted as standard by the Market Street Railway Company and is used exclusively in its lines in San Francisco.

SCIENTIFICALLY CUT LAMP GLOBES.

An invention that undoubtedly will be developed into great utility and that among many other applications, would seem to hasten the adoption of small arc lamps for interior or even desk use, is decribed in the London Journal in an article on "Holophane Globes," which is the name applied to glass globes that are cut on scientific principles for the proper dissemination of light. It is stated that holophane globes, when inclosing any light of high candle power, such as the Welsbach incandescent gas, or the electric lamp, give the appearance of a vase filled with light, brilliant, yet soft while the actual burner or filament cannot be discerned.

The principle of the holophane globe is readily explained. The interior surface of the globe is formed into vertical grooves, which are so shaped as to spread out horizontally the rays proceeding from every part of the light source. The mouldings on the outer surface of the globe are horizontal, and have the effect of distributing the emergent rays in the vertical sense; and inasmuch as the light may be required in some instances to be cast downward and in others to be equally dispersed, the angles of the outside grooves are modified accordingly. This is a very different thing from the unscientific cutting seen in ornamental cut glass globes which do nothing for the diffusion of the light.

As for the loss entailed by the reflection and refraction of holophane globes, it is certified by M. de Nashville to amount in the case of an arc light to from nine to thirteen per cent and as this observer remarks, there is no other kind of globe in existence capable of realizing such diffusion of light and presenting such uniformity of effect. As the loss of light by transmission through clear glass is from eight to ten per cent, the claim that holophone globes do their special work for about four per cent of loss, is well established.

It is pointed out in the Engineering Magazine that the invention of these globes may come in with acetylene lighting now in its very beginnings.

THE LAY PRESS.

POPULAR REFLECTIONS OF THE CONDITION AND PROSPECTS OF ELECTRICAL ENGINEERING ON THE PACIFIC COAST.

A new kind of "hustler" has arisen, and within the past three or four months he has been rapidly multiplying and filling the earth. He is the promoter of new electrical enterprises, and especially the promoter of schemes for the long-distance transmission of electric power. The air of the whole Pacific Coast has all at once become filled with talk about setting up water wheels in lonely mountain places and making them give light and cheaply turn other wheels in towns miles away. From Shasta to San Diego men are organizing, or trying to organize, local or San Francisco companies to utilize in this way the water power in particular localities. A few of these power-transmission enterprises have been successfully organized by business men of capital and the work of establishing them has been actually begun. The rest are yet in the air, and many of them will remain there for a long time.

But the interesting fact is that the State is full of "inquiry" in this direction, and consulting electrical engineers and agents of manufacturers are kept busy answering questions in person and by letter and making preliminary estimates of cost. Their business field is now very active and competition is keen and increasing. Big and little companies have agents here who are after every rumor of a new railway, light, power or other plant, and they keep to themselves every pointer they get to avoid sending a lot of competitors after their customers. Local manufacturing establishments are rapidly going into the manufacture of electrical machinery.

While the actual business done is mainly with new railway and lighting plants and new buildings, the activity over power transmission is the most interesting, if not the most important thing to the general public. The transmission of electric power has just entered upon its second stage. For years it has remained in the stage of theory and experiment.

Great public interest has always been taken in the prophesies of electrical engineers that the vast amount of power running waste in hills and mountains everywhere would be cheaply utilized by transforming it into electrical energy and taking it long distances to where it would be practicable to use it. In this State it has long been a popular and somewhat inspiring idea that the power in the streams and reservoirs of the Sierras would light the towns of the valleys and foothills, and so cheapen power in them that industries would be stimulated. The success of the experiments at Portland, Redlands, the Bodie mines and a few other places, where from twelve to twenty-five miles have been covered, has warranted the various new enterprises which contemplate providing power and light to towns in the Sacramento and San Joaquin valleys and in the foothills. So they have suddenly sprung up in numbers and the stage of practical business has just been fairly entered.

Sacramento is to be the first town to get river power from a distance on a large scale. The big plant near Folsom is to be ready for operation in four or five weeks, and then 5,000 horse-power will be kept pumping into Sacramento over twenty miles away to run the trolley lines and give light and power. The new company is invading the field of the gas company in the light business, and lively competition is promised.

The South Yuba Water Company is getting ready to do big and interesting things in Placer County. It controls an immense water system in Placer and Nevada counties, and has practically unlimited power at its command, and it can be utilized cheaply at high heads The company expects to have in operation by August 1st a plant that will light Newcastle, Penryn and Loomis. It will begin with 150 horse-power and $25,000 plant, with water used at 460 feet pressure. The company is said to plan invading Sacramento, twenty-two miles from Rocklin, with light and

power, and a scheme to operate an electric road from Marysville to Newcastle, along the foothills, is being much talked about.

Another enterprise that has passed the stage of talk is one to supply power to the big groups of mines about the region of Grass Valley and Nevada City. This company, which is composed of miners, proposes to sell power to mines for miles around at $75 per horse-power per year. Heretofore the power used at the mines has been mainly water power, sold by water companies at from $125 to $150 per horse-power.

It is in the mining regions that the use of electric power will naturally be most rapidly developed, and many mining companies are now figuring on establishing plants for their individual use.

One of the most interesting schemes that have been launched is that of the San Joaquin Power Company, which is perfecting plans to bring light and power into Fresno from one of the forks of the San Joaquin River, forty-three miles northeast of Fresno. This company is composed of Fresno capitalists. A San Francisco company has arranged to supply electricity to Bakersfield from a plant in Kern River Canyon, several miles from the city.

These are the only new enterprises in this line which are regarded as having passed the stage of talk. Several are in the air of Southern California, and a half-dozen schemes to electrify Stockton from the Sierras have come to the front since the railroad boom began.—San Francisco Call, June 1, 1895.

The widespread interest that is being taken in plans for the electric transmission of power gives promise that the great need of Californian manufacture is likely to be met within a few years. Capitalists and promoters are actively inquiring into the cost of plants, and the water powers are being grabbed or bought up as rapidly as they can be found. The great need of Californian manufacturers is cheap power. With the nearest abundant supply of coal 600 miles away and with much of the fuel shipped from England and Australia, it is impossible to compete in those lines of manufacture in which power is one of the largest parts of the cost.

But California has abundance of water power within her borders. The rivers and streams that take their rise in the Sierra Nevadas could furnish energy enough to run all the engines in the United States if only it could be harnessed and brought where it can be used. There is now no difficulty in harnessing the power of mountain streams, as electric transmission has reached a stage of progress in which power can be carried many miles with slight loss. The time is not far in the future, if it has not already come, when San Francisco will have the benefit of the power that has been going to waste in the mountains. The energy cannot be brought from the Sierras yet, on a commercial basis at least, but there is good authority for the statement that thousands of horse-power may be brought from Clear Lake and delivered to San Francisco manufacturers at a rate that will drive steam and coal from most of our industries.

The day is undoubtedly coming when the Sierra water powers can be brought to San Francisco, and when that day comes the city will have an unlimited supply of energy at its command. The rapid slopes of the streams that make a descent of three or four thousand feet in a short distance offer a chance to use the same water over and over. The capitalists have awakened to the opportunity. California should lead, rather than follow, in electrical transmission of power. There is both the supply of power and the absence of competition from the fuel supplies that worry the electrical companies elsewhere.—San Francisco Examiner. June 3, 1895.

A dispatch from Fresno says that the owners of the new water and electric plant being put in on the San Joaquin River have offered to furnish power for machine shops of the Valley Railroad, if built in Fresno, at one-half the cost of steam power.

It seems to be an irresistible conclusion that the greater part of the power which can be made available for industrial purposes in California must come directly from the forces of nature. We have no cheap coal in California, or, at least, none has been found as yet, unless we except the Livermore lignite, which has not been fully developed, and imported coal for manufacturing purposes is almost an impossibility, not on account of the forty cents a ton duty, but because of the cost of transportation. But in the mountains of California, from one end of the State to the other, there are rivers, streams and creeks which may be made a source of supply for power almost infinite. To convert the dynamic force of running water into electrical energy is one of the simplest of modern scientific problems, and the only practical difficulty is the economical transmission of the electric force over long distances.—San Francisco Chronicle, May 17, 1895.

The scheme for transmitting power from the north fork of the San Joaquin River to Fresno has been in contemplation, in one form or another, for a long time, but the work went forward so quietly that the public did not learn that any actual steps had been taken until operations had begun. Work has now been going on for some weeks on the canal by which water will be led from the north fork to the reservoir, a distance of six miles, following the line of canal. * * * * *
It is not too much to say that a new era has dawned for Fresno and the surrounding country. The drawback heretofore has been that fuel was so expensive that manufacturing was at a disadvantage, especially where much power was used. This is now to be reversed. Power will be cheap, permanent and convenient, and coal will be known in Fresno no more, except, perhaps, in a few cases where electricity cannot be made to answer the purpose, which will mark the dawn of a day such as the San Joaquin Valley has never seen.—Fresno (Cal.) Republican, May 12, 1895.

News of the Month.

TELEPHONE AND TELEGRAPH.

RIVERSIDE, CAL.—H. H. Streeter has been granted a telephone franchise.

NAPA, CAL.—L. Grothwell, of San Francisco, has applied for a franchise for the erection of telephone and telegraph lines from Napa to Calistoga.

GREAT FALLS, MONT.—Rapid progress is being made in the construction of the new telephone line from Great Falls to Lewistown, a distance of fifty-three miles.

SACRAMENTO, CAL.—The Board of Supervisors have posted notice of sale on June 24th of a franchise for the construction, operation and maintenance of a telephone and telegraph system in Sacramento County. Evidences of having secured at least 400 bona fide telephone subscribers must be presented.

MISCELLANEOUS.

PORTLAND, OR —A school for electricity has been established under the direction of Professor Loverage.

SACRAMENTO, CAL —The Electro-Chemical Amalgamating Co. has been incorporated. Calvin Brown is one of the Directors.

LOS ANGELES, CAL.—The Dheuy Oil Company does its oil pumping by electricity, using the Commercial Electric Company's motors.

SPRAGUE, WASH.—Lightning entered the station of the Sprague Electric Light Works on May 18th, doing damage that necessitated a week's shut down.

OREGON CITY, OR.—F. E. Ball of the Electrical Reduction Works has gone to Southern Oregon to exploit his electrical method of reducing refractory ores. His assistant, E. F. Kennedy, accompanies him.

SAN JOSE, CAL.—The Electrical Improvement Company has paid Giovanni Giraudi $2,000 as judgment and $774 as interest and costs for the loss of his right hand by an injury received from contact with an electric light wire on the roof of a house at night in a storm.

LA CENTER, WASH.—A Clark County lumberman has erected a plant consisting of an electric motor driving a drag saw. With this equipment it requires but three minutes for the saw to cut through a five foot log, and the saw cuts on an average 100 cords of wood a day.

SAN FRANCISCO, CAL —Neil Cameron, a lineman of the Fire Alarm system, has brought suit against the W. U. T. Co. and the city to recover $20,000 damages for personal injuries, alleged to have been caused by the falling of a telegraph pole upon which he was working.

SAN FRANCISCO.—The Municipal Signal Company, of Boston, has served notice on the Board of Supervisors that the city will be held responsible for its use of the police signal system in service, alleged to be an infringement of patents owned by the company named.

BERKELEY, CAL.—Suit has been entered by C. W. McLaughlin against the Western Union Telegraph Company for damages in the sum of $5,250, for failure to deliver a message owing to a mistake made by an employee in making the name "Dietz" appear as "Dieth."

TACOMA, WASH.—Electricians Bochelet and Fraser have entered into a contract with the Northern Pacific Railway Company to recover a safe that was lost in the bay during a recent landslide and which cannot be found. The electricians propose to locate the safe by electro-magnetic means.

PORTLAND, OR.—The General Electric Company has brought suit against the receiver of the Oregon Railway and Navigation Company to recover damages in the sum of $63,916.43 for the loss

of electrical machinery by fire on September 23d last, such machinery being consigned to the Portland General Electric Company.

SAN FRANCISCO.—Suit has been entered by C. C. Terrill and the German Savings and Loan Society against Fabian and Margaretha Joost, to foreclose two mortgages aggregating $141,000, which sum represents money borrowed to assist the San Francisco and San Mateo Electric Railway out of its financial difficulties some time ago.

TRANSMISSION.

PERRIS, CAL.—It is possible that the San Antonio Light and Power Company will extend its 10,000-volt circuit to this city.

VISALIA, CAL.—Satisfactory progress is being made in the negotiations for the transmission of electric power from the Kaweah River to this city.

PHŒNIX, ARIZ.—The great Walnut Grove dam may be rebuilt, and if so an electric power plant of considerable magnitude will be installed.

SAN DIEGO, CAL.—An electrical engineer is figuring on a plant to supply this city with electric power from a waterfall on the flume line of the San Diego Flume Company.

SILVERTON, COL.—The 150 h. p. general electric generator and Pelton wheel installed in the Silver Lake mines last August by E. G. Stoyber, has been supplemented by a duplicate equipment.

SAN JOSE DE COSTA RICA.—Considerable electric work is being installed in this vicinity, one of the latest orders being for a 150 h. p. General Electric generator with Pelton wheels, for this city.

FALL RIVER MILLS, CAL.—A company represented by a Mr. Gale expects to put in an electric plant at the falls and irrigate the plains between Fall City and Burgettville, an area of 15,000 acres.

SALMON CITY, IDAHO.—The Gold Dredging Company has installed a 150 h. p. Pelton water wheel and a 100-kilowatt General Electric generator. These are direct connected and used in general mining work.

SPOKANE, WASH.—A warranty deed has been filed conveying from the Spokane Falls Water Power Company to the Northwest Milling and Power Company all its title to the water power of the Spokane Falls in consideration of $400,000.

PROVO, UTAH.—A large party of engineers and laborers, in charge of F. J. Kramer, have commenced work on the Provo power transmission plant in Provo Canyon. This enterprise is under the financial management of L. L. Nunn, of Telluride, Colorado.

SAN JOSE, CAL.—Charles Franklin, of San Francisco, owner of a valuable water right in the Santa Cruz Mountains, twelve miles from this city, is considering electrical transmission therefrom to San Jose. The stream is said to be capable of generating 10,000 h. p.

QUEZALTENANGO, GUATEMALA.—The Pacific Mail steamship Colima, recently wrecked off the west coast of Mexico, contained a shipment of Pelton water wheels that were to have displaced the turbines in use in the central station in this city. The order has been duplicated.

HIDALGO, MEXICO.—The Cia. Anonima de Transmission Electrica de Potencia has installed a 2,000 h. p. mining transmission plant, consisting of five 3-phase General Electric generators direct coupled to Pelton water wheels running under an 800-foot head. The transmission is of 10,500 volts.

SALT LAKE CITY, UTAH.—Indications point to a very spirited rivalry between the two Big Cottonwood enterprises. Each expects to place 3,000 h. p. of electric power upon the Salt Lake City market before the year is ended. These companies are the Utah Power Company and the Big Cottonwood Power Company.

TRANSPORTATION.

NAPA, CAL.—A company is being organized for building an electric road to Calistoga.

ONTARIO, CAL.—The power house for the new Ontario street railway is about completed.

REDLANDS, CAL.—An electric railway to Hemet via Moreno and San Jacinto is being considered.

SAN FRANCISCO, CAL.—The Board of Supervisors is considering plans and models of car guards or fenders.

VISALIA, CAL.—The talk of building an electric road from Merced into the Yosemite Valley is being revived.

PETALUMA, CAL.—The construction of an electric railroad between this city and Santa Rosa is believed to be a certainty.

SANTA MARIA, CAL.—Messrs. W. T. Lucas et al. have applied to the County Supervisors for an electric railway franchise.

PORTLAND, OR.—The City and Suburban Railway Company is operating a large trolley street-sprinkler with great satisfaction.

PASADENA, CAL.—The new line of the Pasadena and Los Angeles Electric Railway Co. was formally opened for business on May 6th.

SAN RAFAEL, CAL.—The newspapers favor the construction of an electric road to run from San Rafael to Ross Valley and Point San Pedro.

NAPA, CAL.—It is stated that Eastern parties are about to apply for an electric railway franchise extending from Napa into Lake County.

HAYWARDS, CAL.—Messrs. Chisholm & Petermann have been granted a franchise for an electric road from Haywards to Mount Eden and Alvarado.

SACRAMENTO, CAL.—The Central Electric Railway Company is erecting a toboggan slide in East Park to cost $1,000. It will be run by electricity.

LOMPOC, CAL.—Dr. Lucas et al. has applied for a 50-year franchise for an electric road to run from Wigington, through Santa Maria to the ocean.

BERKELEY, CAL.—The horse-car track on University avenue, between East and West Berkeley, is being bonded, and cars have been ordered preparatory to changing to an electric equipment.

LOS ANGELES, CAL.—The boilers and the foundations for the engines and generators of the Los Angeles Traction Co. are being erected and are expected to be in operation by the 1st of July.

PASADENA, CAL.—Work is progressing steadily on the new electric railway forming the extension of Professor Lowe's mountain railway, and it is expected that the line will be completed to Crystal Springs by July 1st.

STOCKTON, CAL.—H. T. Compton, Consulting Engineer of the Lodi Electric Railway, states that the preliminary survey has been finished from this city to Lodi. Plans will be ready for the contractors in a few days.

SANTA CRUZ, CAL.—A colored porter employed about the car-house disregarded warnings and "fooled" with the equipment of a car which started the car on a run away up the street, smashing the car and tearing out the side of a house.

SANTA ROSA, CAL.—Leading business men are considering the feasibility of connecting the valleys of Napa and Sonoma counties with an electric belt railway, having its terminus at tidewater, there to connect by fast ferry service with San Francisco.

SAN FRANCISCO.—The Market-street Railway Company is improving the Bryant-street power house by the addition of four 1,200 h. p. triple expansion engines, and direct connected Siemens-Halske generators with necessary boilers, etc. The engines are now being constructed by the Union Iron Works, and when completed the plant will supply power for the operation of the Mission, Folsom, Bryant, Sixteenth, Kentucky, Third and Kearny streets systems.

MARYSVILLE, CAL.—Work has been commenced on the electric road to be built from Marysville eastward through the foothills of Yuba and Madera counties and southeast to Auburn. It will cover nearly fifty miles of track, and when complete it will be the longest line of electric road west of Chicago. The purpose is to afford the orchardists and farmers in the foothills easier facilities for getting their produce to market and at a lower cost. Passengers will be carried, as well as freight, and power will be supplied by the South Yuba Water Co.

PORTLAND, OR.—A party of Scotch capitalists accompanied by their own engineer, proposes to purchase the street railway system of Salem and to bond it for $200,000. It is also announced that this party is negotiating the consolidation of the entire street railway service of Portland excepting the cable road to Portland Heights. This consolidation involves an investment of $3,000,000 and will take in 115 miles of street railway tracks owned by the East Side Company, running from Portland to Oregon City with lateral lines at several points, the Portland Consolidated Street Railway company and the City and Suburban Street Railway company with lines traversing the city in all directions.

SAN FRANCISCO.—The electric trolley road now being built on Fillmore street will encounter a grade of 25.5 per cent. between Green and Vallejo streets, and a grade of 24 per cent. between Vallejo and Broadway, to overcome which the Market-street Railway Company proposes to place an underground cable under each track; this cable running over sheaves at the top and bottom of the hill. The cable will be run around the sheaves after the manner of an ordinary cable road, and will be operated by an electric motor geared to the sheave at the top of the hill. No ordinary form of grip will be provided on the cars, but instead a special grip will be hooked on to the car, securing it rigidly to the cable.

RIVERSIDE, CAL.—Professor Baldwin, President of the San Antonio Light and Power Company. of Pomona, in a recent lecture, named Mill Creek, Lytle Creek and the Santa Ana and San Jacinto rivers as among the best streams to be relied upon to furnish power the year round in this portion of Southern California. Electric power could be delivered in Riverside from the San Jacinto at a cost of $125,000 for 300 h. p., and he advised the City Trustees to change their call from $40,000, to be voted for a municipal lighting plant, to $125,000.

NEW WESTMINSTER, B. C.—F. S. Barnard, M. P., manager of the Consolidated Railway and Light Company, proposes to develop the water power of Seymour Creek at a cost of $200,000, in the event of a bonus of $50,000 from the city and the acceptance of a proposal to light the city at 25 per cent less than the present cost, the bonus named to be used in the construction of a railroad from Sapperton to Stevenson. The project contemplates the delivery of 1,000 h. p.

SACRAMENTO, CAL.—The contract between the Central Electric Railway Company and the Capital Gas Company, by which the latter furnishes electric power for street railway purposes, expires on June 30th, by which time the electric transmission from Folsom must be in operation. Superintendent T. A. W. Shock, of the Sacramento Power and Light Company, states that the Folsom transmission will be started by June 24th, when the first equipment of 1,000 h. p. will be in operation. Of this 300 h. p. will be required by the railway and the balance will be for sale. In all 280 men are now employed on the work. A movement is on foot to celebrate the completion of the Folsom transmission by an electric carnival, to be held during the State Fair.

GRASS VALLEY, CAL.—Contracts have been awarded by the Nevada County Electric Power Company to the Stanley Electric Manufacturing Company, through Martin & Lindner, for two 300-kilowatt Stanley two-phase generators, and to the Pelton Water Wheel Company for two Pelton wheels to drive the same. The plant will be located on the South Yuba River, where 2,500 h. p. can be developed with comparative ease, driving the wheels under a head of 250 feet. The transmission circuit will run direct to Nevada City, whence a loop circuit will be continued for a distance of nine miles from the power-house, embracing Grass Valley and seven groups of mines. The contracts just awarded are for the initial installation.

FRESNO, CAL.—A gang of men is at work on the canal to furnish water from the North Fork of the San Joaquin River to the power house for the Fresno transmission. An impounding reservoir, to contain 3,500,000 cubic feet of water, and which amount can easily be doubled, will be readily constructed by throwing up a low embankment. The pipe line to the power house will be 4,000 feet long, delivering water at a head of 1,410 feet. Pelton wheels, each having a capacity of 400 h. p., are to be used, and it is proposed that the generators will deliver current at 550 volts, which will be raised to 11,000 volts for transmission and delivered in Fresno, a distrnce of 33 miles, at a loss of 10 per cent. The initial plant will have a capacity of 1,000 h. p. The corporation is backed with Chicago capital.

LIGHTING.

TINTIC, UTAH.—The new electric light plant has been started.

LEWISTON, IDAHO.—W. A. Smith has applied for an electric light franchise.

ARCATA, CAL.—The new arc and incandescent plant will soon be in operation.

CHICO, CAL.—Bids for an electric light franchise will shortly be advertised for.

VERNON, B. C.—The question of a municipal electric lighting plant is again agitated.

COLTON, CAL.—The question of a municipal electric lighting plant is being agitated.

HAILEY, IDAHO.—The electric light plant has been leased to John Hart for one year.

KAMLOOPS, B. C.—An electric lighting plant is to be placed in the Slocan Star mine.

ASTORIA, OR.—The river steamer Telephone is having an electric light plant installed.

ALAMEDA. CAL.—The city has concluded to furnish incandescent service at meter rates.

BUTTE, MONT.—The electric light company is constructing a 40- by 120-foot addition to its plant.

BODIE, CAL.—Part of the Three Mile Post mine on the Hawthorne Road is lighted by electricity.

VENTURA, CAL.—The Board of Trustees has approved of specifications for an electric lighting plant.

MISSOULA, MONT.—The electric light company will soon begin work on a new power dam to cost $100,000.

SONORA, CAL.—An electric lighting plant is to be placed in the Miller & Holmes mine at Quartz Mountain.

CHICO, CAL.—The public are demanding the installation of an electric lighting plant by the local gas company.

NEW WESTMINSTER, B. C.—A proposition is on foot for the sale of the municipal lighting plant and water works.

BOULDER, MONTANA.—Frank Bernatz is considering a plan for the erection of water works and an electric lighting plant.

VICTORIA, B C.—The municipal lighting plant has been increased by the addition of two 60-light Wood arc dynamos.

FLORENCE, COL.—The new cyanide mill of the Metallic Extraction Company has installed an 8½-kilowatt incandescent plant.

SPOKANE, WASH.—The new Court House is to have an electric lighting plant. Address A. L. Thorp, Chairman, Spokane, Wash.

PASADENA, CAL.—The Pasadena Electric Light & Power Co. is installing a new 250-horse-power engine, and a 1200-light alternator.

VICTORIA, B. C.—M. Hutchinson has been elected general superintendent and chief engineer of the Municipal Electric Light Works.

SALT LAKE CITY, UTAH.—The Citizens Electric Co. has purchased a site for its power house, and is rapidly pushing work on its new plant.

OROVILLE, CAL.—A franchise for an electric lighting plant in the towns of Gridley and Biggs has been sold to T. C. Blair and L. H. Williams.

SAN BERNARDINO, CAL.—An electric lighting plant and a 20 h. p. electric motor, is to be placed in the Southern California State Asylum.

SEATTLE, WASH.—The Seattle Electric & Gas Fixture Co. have obtained the contract for the electric lighting plant of the new State University.

HELENA, MONT.—H C. Sterling has been appointed Superintendent of the Helena Power and Light Company, vice J. A. Tupper, resigned.

HELENA, MONT.—The Capital Lighting Company having secured the city contract, will send Manager J. A. Tupper East for additional equipment shortly.

RIVERSIDE, CAL.—The special election recently called, voted to incur an indebtedness of $40,000 for the construction of a municipal electric lighting plant.

CRIPPLE CREEK, COL.—The Gold and Silver Extraction Company of America (Limited) has placed a 6-kilowatt Edison dynamo and incandescent plant in its new cyanide mill.

SAN MATEO, CAL.—The San Mateo Electric Light Company, recently incorporated by F. M. and F. A. Greenwood et al., has applied for a franchise to erect pole lines for lighting the city.

MILL VALLEY, CAL.—The San Rafael Gas and Electric Light Company is stringing wires between San Rafael and Mill Valley, and will furnish incandescent service in Mill Valley early in July.

SAN FRANCISCO, CAL.—It is announced by J. B. Crockett, President of the San Francisco Gas Light Co., that that company is to erect an electric light and power plant, costing about $3,000,000.

SAN JOSE. CAL.—The San Jose Lighting Company has been incorporated with a capital stock of $250,000. The Directors are C. F. Wilcox, R. L. Slack, J. R. Patton, William Sumner and J. J. Southheimer.

AUBURN, CAL.—The Republican states that the South Yuba Co. will have its lighting service in operation in Newcastle, Penryn, Loomis and Rocklin by July 1st. It is to be a water power plant under a head of 483 feet.

BOISE CITY, IDAHO.—The people of the New Plymouth colony, Payette Valley, propose to construct a canal three miles long and build an electric plant for lighting the village. Wm. E. Smythe is the father of the colony.

LOS ANGELES, CAL.—Bids were received until June 20th for the furnishing of materials and labor for the erection of an electric lighting plant, to cost less than $10,000, at the Pacific National Home for D. V. S.

SALT LAKE CITY, UTAH.—An ordinance has been passed fixing the maximum height of the electric light poles at thirty feet, the lowest at twenty-three feet on paved streets, the maximum height at twenty-seven feet on unpaved streets.

OAKLAND, CAL.—The contract for lighting the city by gas and electricity for the fiscal year ending June 30, 1896. has been awarded the Oakland Gas Light and Heat Company, which voluntarily made a reduction of $5,000 in the contract price.

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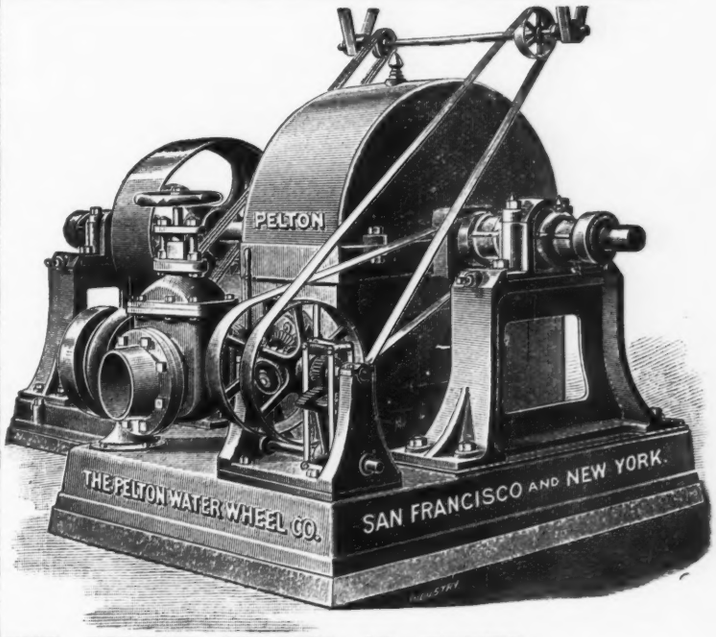

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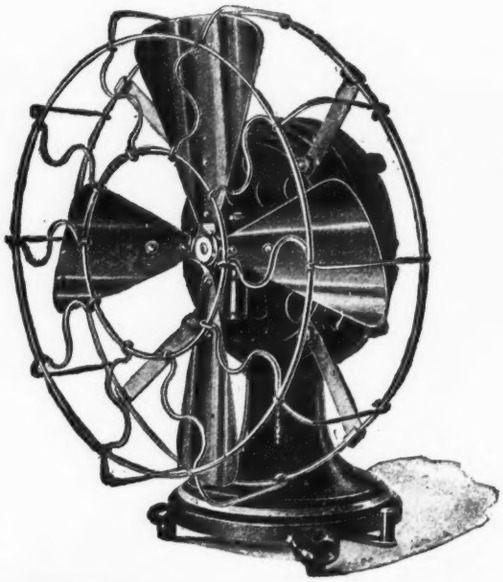

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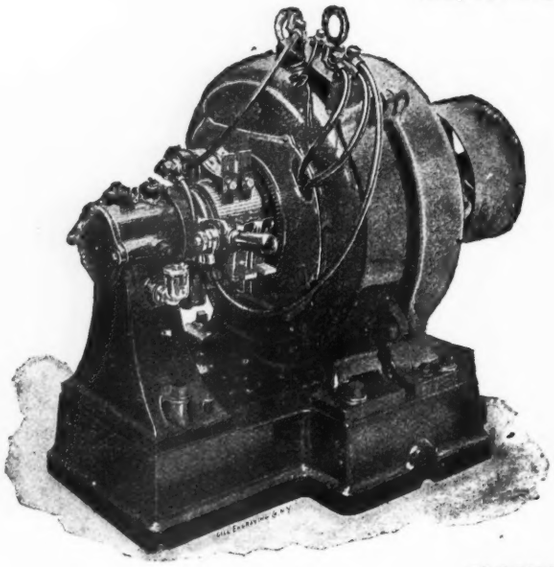

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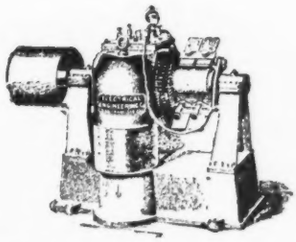

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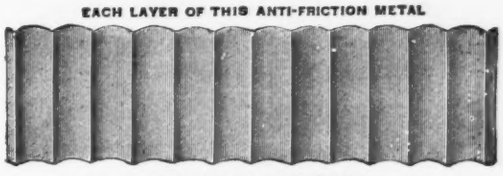

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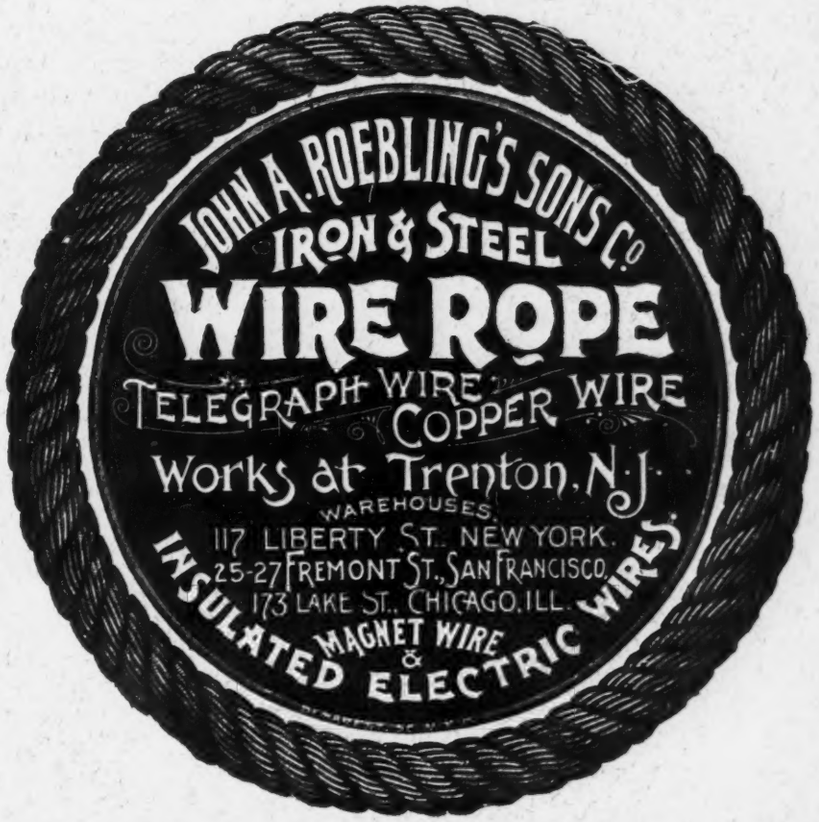

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WESTINGHOUSE ELECTRIC AND MANUFACTURING CO.,

PITTSBURG, PA.